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Celebrating the 125th anniversary of the Astronomical Observatory of Belgrade

FUTURE SCIENCE
WITH METRE-CLASS TELESCOPES

Belgrade, 18-21 September 2012

Edited by
Srđan Samurović, Branislav Vukotić and Miroslav Mićić

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Future Science With Metre-Class Telescopes

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2013

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INTERNATIONAL BELISSIMA CONFERENCE

Belgrade, 18-21 September 2012

Tulip Inn Putnik Belgrade Hotel

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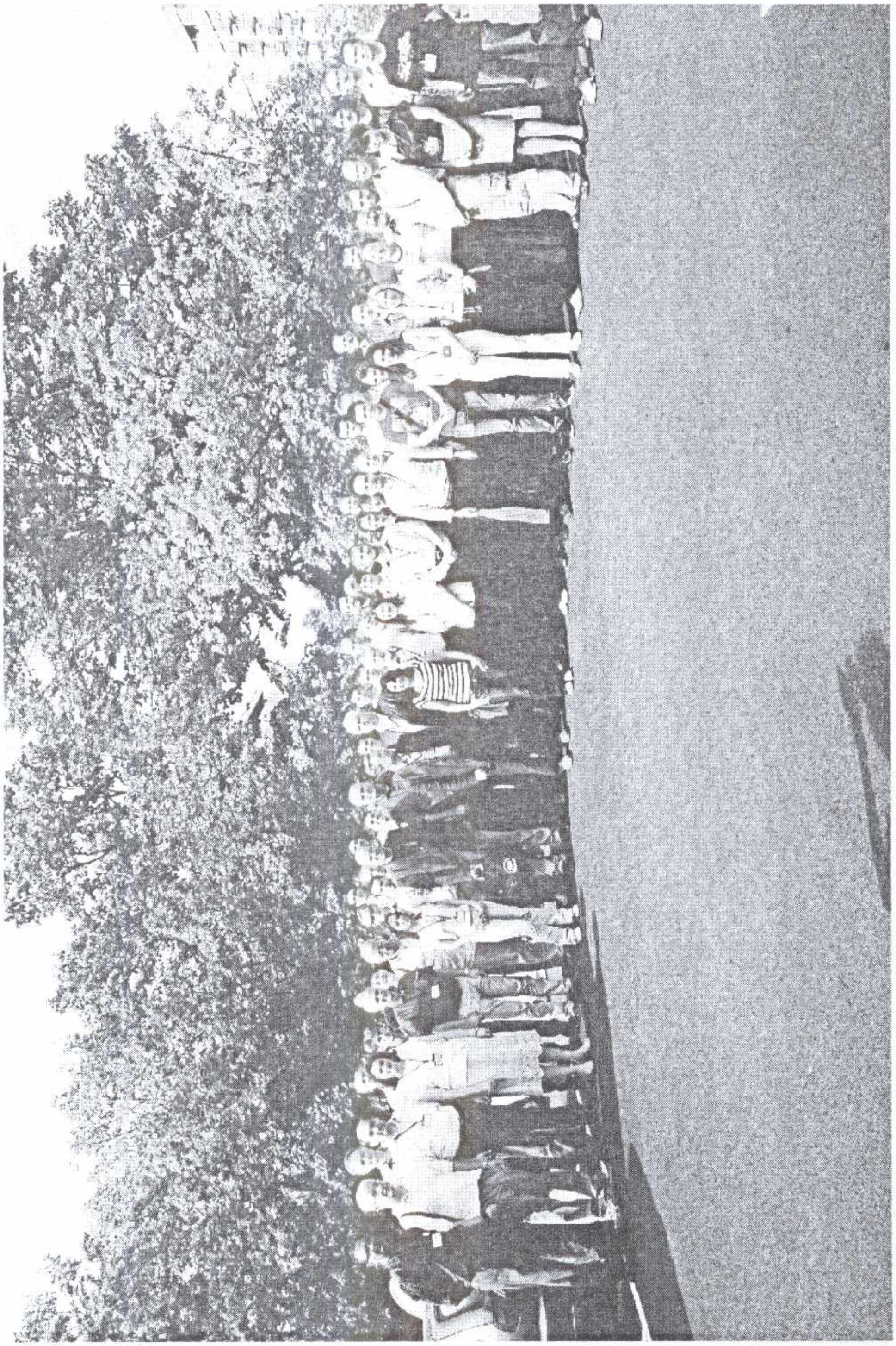

Photo: Dr. Miodrag Dačić

CONTENTS

Metre-Class Telescopes and Instruments

Networked Telescopes, Networked Science

Education and Public Outreach

Celebrating 125 Years of the Astronomical Observatory

Posters

PREFACE

"Future Science with Metre-Class Telescopes" conference has been envisioned as a scientific pinnacle of one of the most ambitious infrastructural projects in the history of Astronomical Observatory Belgrade (AOB). Obtaining and installing a metre-class telescope ("Milanković" telescope) is at the core of BELISSIMA (BELgrade Initiative for Space Science, Instrumentation and Modelling in Astrophysics) project, the three-year FP7 REGPOT project started in July 2010. Parallel to the development of the technical specifications and the telescope manufacturing, a great effort by the BELISSIMA team has been dedicated to the education, training and outreach to the astronomical and general public in Serbia with the idea to explain and bring closer to focus, scientific potential of the future "Milanković" telescope. With that in mind, three meetings have been organized in 2010 and 2011. The first one brought together local astronomical community to discuss the need for a telescope of this kind. The next two events, "Network of Telescopes in the Western Balkans Region" and "Science with 1.5m telescopes" served as a fertile ground for establishing collaborations between local professionals and researchers from the top international observational facilities.

This was the fourth meeting to further develop exchange of ideas with the international community of astronomers. The conference entitled "Future Science with Metre-Class Telescopes" took place in 2012 at the Tulip Inn Hotel, Belgrade, from October 18th to 21st. The beginning of the conference was dedicated to the instrumentation on already existing metre-class telescopes at numerous observatories and the role of small telescopes in a modern-day astronomy. This was followed by a detailed overview of those research topics where metre-class telescopes will dominate in the future: determining asteroid properties from the photometric observations; the search for exoplanets; studying eclipsing binaries, emission nebulae; gravitational microlensing; lensed supernovae. A large portion of the discussion has been dedicated to the networked telescopes and education and public outreach. The final day of the conference celebrated the 125th anniversary of the Astronomical Observatory Belgrade.

We thank the participants for their high-level contributions and for being extremely cooperative in submitting their abstracts and later, their contributions, on time and in a format that allowed us to produce these proceedings. We thank the members of the Scientific Organizing Committee (SOC) for their work in the preparations of the BELISSIMA conference. We also thank the members of the Local Organizing Committee (LOC) who ensured that the conference ran smoothly. Finally, we thank our colleagues from the AOB who took part in peer-reviewing of the contributions.

This conference was made possible through support provided by the European Commission through BELISSIMA call FP7-REGPOT-2010-5, contract no. 256772. We also acknowledge the support from the Ministry of Education, Science and Technological Development of the Republic of Serbia through project no. 176021 "Visible and Invisible Matter in Nearby Galaxies: Theory and Observations".

The Editors,
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THE BELISSIMA PROJECT

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Abstract. We present the BELISSIMA project, the most ambitious infrastructural project currently active at the Astronomical Observatory of Belgrade, its goals and achievements. The importance of the project for the future of the astronomy in Serbia will also be addressed.

1. INTRODUCTION

BELISSIMA (BELgrade Initiative for Space Science, Instrumentation and Modelling in Astrophysics) is the three-year FP7 REGPOT project started in July 2010. The project is coordinated by the Astronomical Observatory of Belgrade (AOB) and is its most ambitious infrastructural project currently active. The project was evaluated very favourably by the European Commission and obtained 14.50 out of 15.00 points; its "scientific and/or technological excellence" was highly regarded and BELISSIMA obtained maximal 5.00 points. The approval of the project was thus explained: "The BELISSIMA is an excellent project which is perfectly targeted and very clearly described. (...) The proposal to upgrade the research capacity of the AOB is based on the excellent competence and research activities which are on the cutting-edge of astrophysics and astronomy".

The BELISSIMA project consists of five work packages (WPs) which are listed below with their leaders. The Management board of BELISSIMA consists of the leaders of the WPs given below and the coordinator of the project is Srdjan Samurović. The WPs (and their leaders) are:

1. Preparations and reinforcement of AOB (leader: Zoran Knežević)
2. Purchase, installation and testing of optical equipment (leader: Ištvan Vince)
3. Human potential, training and public outreach (leader from March 2011: Miroslav Mićić; from July 2010 to March 2011 the leader was Luka Č. Popović)
4. Dissemination and promotional activities (leader: Milan Ćirković)
5. Project management (leader: Srdjan Samurović)

2. GOALS AND ACHIEVEMENTS

The most important goals and achievements of each WP of the BELISSIMA project are presented below.

2. 1. WP1. PREPARATIONS AND REINFORCEMENT OF AOB

From the very beginning of the BELISSIMA project, the procedure for increasing and improving human resources of the AOB took place in parallel with activities performed in other WPs. The Management board of the BELISSIMA project started from the beginning of 2010 (as soon as the positive outcome of the proposal was announced) to intensify the contacts with candidates for a total of 72 months of engagement intended for recruited researchers. This task, which required a significant knowledge of the local legal procedures, was successfully handled by Director of AOB, Zoran Knežević, the head of WP1.

The first researcher, Milan Bogosavljević was hired on July 15th, 2010. Milan Bogosavljević was born in Niš in 1977. He graduated from the University of Belgrade, Faculty of Mathematics, Serbia and obtained his PhD from California Institute of Technology (CalTech). He is an expert in observational astronomy with a significant experience with observations with the world's largest telescopes (such as Keck). Immediately after his hiring M. Bogosavljević was appointed technical director of the Vidojevica Astronomical Station (VAS) and initiated his numerous activities which included several trips abroad and contacts with foreign experts related to the design and construction of the planned telescope "Milanković" to be mounted at the VAS.

The second researcher, Miroslav Mićić was hired on March 16th, 2011. Miroslav Mićić was born in Belgrade in 1977. He graduated from the University of Belgrade, Faculty of Mathematics, Serbia and obtained his PhD from the Pennsylvania State University. He joined the BELISSIMA project coming from the University of Sydney where he had been working. He is an expert in astrophysical simulations, astronomical data processing and visualization of astronomical data and his activities include several research projects with young researchers at the AOB based on numerical astrophysical simulations; he was appointed leader of WP3 of the BELISSIMA project.

Soon after the international BELISSIMA conference, on November 1, 2012, the third researcher was hired within the scope of WP1: Milica Mićić, born in Kruševac in 1984, graduated from the Department of Mathematics at the University of Belgrade in June 2008 and later, in December 2008, also obtained the masters degree there. She obtained her PhD at the Institute for Theoretical Astrophysics at the University of Heidelberg (Germany). Milica Mićić is an expert in numerical astrophysical simulations in the field of massive star and molecular cloud formation, focusing on the influence of chemical processes on the gas dynamics and is also an expert in astronomical data processing and visualization of astronomical data.

At present all three hired researchers are fully integrated in the AOB environment and participate in the work of the project no. 176021, "Visible and Invisible Matter in Nearby Galaxies: Theory and Observations", led by a coordinator of BELISSIMA, S. Samurović and funded by the Ministry of Education, Science and Technological Development of the Republic of Serbia. They will be offered permanent positions at the AOB after the end of the BELISSIMA project in July 2013.

2. 2. WP2. PURCHASE, INSTALLATION AND TESTING OF OPTICAL EQUIPMENT

From the beginning of BELISSIMA the Management board of the project began to work on the selection of the optimal configuration of the robotic 1.50m-class telescope to be purchased and mounted at the top of Vidojevica. The telescope will be named "Milanković" after the famous Serbian astronomer. Several manufacturers of telescopes were contacted and they provided their estimates of prices. The additional funds for the purchase and the building of the dome are obtained from the Ministry of Education, Science and Technological Development of the Republic of Serbia through the aforementioned national project no. 176021 that gathered 26 researchers from leading research institutions of Serbia. Their agency JUP (Jedinica za upravljanje projektom, Project Implementation Unit) was authorized by the AOB to perform the tender procedure on its behalf. At the time of this writing (May 2013) the negotiations with the manufacturers were finished, the details of the contract for the purchase of the 1.50-m class robotic telescope "Milanković" are established and it is expected that it will be signed before July 2013. In order to prepare the accurate documentation and to secure the best performance of the future telescope, numerous contacts with foreign experts were made (see also below).

2. 3. WP3. HUMAN POTENTIAL, TRAINING AND PUBLIC OUTREACH

Throughout the whole duration of the BELISSIMA project numerous activities pertaining to human potential, training and public outreach were performed and below only the brief list is given. The reader is referred to the BELISSIMA Web site (see below) for the detailed information.

At the beginning of the project two events were organized. First, on September, 6th 2010 at the AOB the meeting of the Serbian astronomical community was organized and 40 colleagues from the AOB, Department of Astronomy (Belgrade University), Institute of Physics (Belgrade) and People's Observatory from Belgrade took part in the discussions related to the needs of the community regarding the new telescope. The second event was organized three weeks later: the executive meeting of the BELISSIMA project took place in Prokuplje, from 27th to 28th September 2010. The meeting "Network of Telescopes in the Western Balkans Region" gathered 30 participants, of which 13 were foreign experts from several European countries.

Numerous visits to various European observatories and institutes were organized: Orliakas Astronomy Station in August 2010; meeting "Big Science With Small Telescopes" held in Dornburg, near Jena, Germany, from October, 19th to 22nd 2010; observations at the Baja Observatory, Hungary (February 2011), visit to the telescopes at Tenerife and La Palma (February/March 2011); "Second Workshop on Robotic Autonomous Observatories" held in Malaga, Spain from 5th to 10th June 2011; "Hands-on Strong Gravitational Lensing School" held at Excellence Cluster Universe, Garching, Germany from 14th to 17th June 2011; summer school "Opto-Mechanical Design in Astronomy" which was held at the Astrophysical Institute of Potsdam (AIP) in Potsdam, Germany from June 20th to 23rd, 2011; the observing NEON school held at Molutai Astronomical Observatory (Lithuania) from July 14th to 27th, 2011.

Two long-term (six months in total) visits of the members of the AOB staff were organized in collaboration with the Leibniz Institute for Astrophysics (AIP) in Potsdam, Germany. First, Monika Jurković visited the AIP from April to June 2012 for the purpose of training with the new instruments to be put on the "Milanković" telescope to be purchased through the BELISSIMA project and the techniques of observations to be performed with it. She participated in the work of the Stellar Activity research group at the AIP. The main aim of her project was to derive stellar parameters like effective temperature, gravity and metallicity from the database of the STELLA robotic telescopes, which are located on Tenerife. The second researcher who visited the AIP was Milena Jovanović: she visited the AIP form June to August 2012 where she joined the Stellar Activity group and in particular the part of it connected to the STELLA project. STELLA is an observatory hosting two robotic 1.2 m telescopes (STELLA-I and STELLA-II) that operate in fully unattended mode (see the contribution of the STELLA project manager M. Weber, who supervised the two visits, in these Proceedings).

Also, foreign researchers came to the AOB after the invitation of the BELISSIMA project: Zach Ioannou (presently at the Sultan Qaboos University, Oman, see his contribution in these Proceedings) came from Thessaloniki to Belgrade where he stayed from March 28th to April 2nd 2011. Z. Ioannou is one of the creators of the Astronomical Station Orliakas. He came for two reasons: to help with the writing of the technical documentation regarding the construction and purchasing of the telescope "Milanković" (see above) and scientific collaboration with AOB. Although his advices were mostly technical ones (parameters of the various parts of the telescope, details of the construction etc.) he also provided the participants of BELISSIMA numerous administrative details regarding European tenders.

For the purpose of training of the AOB staff various activities were performed, such as: training at the VAS, training course related to photometry and spectroscopy held at AOB in May 2011 by Ištvan Vince and data reduction training at the AOB.

One of the main dissemination activities of the BELISSIMA project (see also below) was the production of a series of TV programmes aimed at a wide non-expert audience but since some such activities belong to WP3 we present them in this subsection. So far (May 2013) four TV episodes were shot and edited, whereas the remaining two will be finished by the end of BELISSIMA. The first episode is mainly dedicated to the VAS, the second episodes shows the AOB, its activities and projects and is focused on the 125th anniversary of one of Serbia's oldest and most successful scientific institutes. The third and fourth episodes are dedicated to the international BELISSIMA conference held in Belgrade in September 2012 and many of the speakers took part and presented their work. These two episodes will be subtitled in both Serbian and English in order to reach the widest possible audience. Before the end of BELISSIMA the production of the multimedia DVD aimed at the local lay audience is planned: the disk will include various video materials, audio recordings and photographs accompanied with the written information.

2. 4. WP4. DISSEMINATION AND PROMOTIONAL ACTIVITIES

Since one of the requirements of FP7 projects is communication, dissemination and exploitation of the results of the project, the Management board of BELISSIMA engaged with the public and with the media on numerous occasions to discuss the project, its accomplishments, its activities and the plans for the future. Here only a few dissemination and promotional activities are listed (the production of the BELISSIMA TV programme and multimedia DVD was addressed above, when the activities done within WP3 were described): the all-sky camera at the VAS recorded on November 12th, 2010 is (to the best of our knowledge) the only image of the meteor entering the atmosphere above Serbia and numerous media have published it thus promoting the BELISSIMA project, the VAS and AOB in public; AOB had the honor on November, 8th 2010 to host Prof. Sir Arnold Wolfendale, FRS, 14th Astronomer Royal and the participants of the BELISSIMA project discussed with him numerous issues; BELISSIMA has participated in the 4th Festival of Science held in Belgrade in December 2010; an article which describes the BELISSIMA project and telescope "Milanković" were published in the illustrated Serbian almanac "Danica" (Samurović 2011, 2012a, 2013); several BELISSIMA participants took part in various radio and TV programmes; the cooperation with Amateur Astronomers Association of Serbia has started from the very beginning of the work of the BELISSIMA project; the BELISSIMA project collaborated with the researchers from Serbian town of Niš through various initiatives – we mention here only one: Goran Sv. Djordjević who leads Southeastern European Network in Mathematical and Theoretical Physics organized a seminar "Trends in Modern Physics" for the elementary and high school teachers from Balkan countries and neighboring regions, held in August, 2011 in Niš and in agreement with the BELISSIMA project the teachers were taken to the VAS and the first TV material related to BELISSIMA was shot there (see above); several BELISSIMA participants took part in the activities of the Research Center in Petnica. The AOB brochure dedicated to the AOB, its history, its present activity and its future which will be marked by the "Milanković" telescope was published in December 2011. The booklet printed in two versions (Serbian and English) is in an accessible language and presents active projects, their leaders and participants. A special attention was given to the BELISSIMA project which is covered in detail. The first BELISSIMA Workshop was organized from 13 to 14 October 2011, after the 16th National Conference of Astronomers of Serbia: it gathered approximately 50 participants out of which 21 were foreign experts who discussed with the BELISSIMA participants various aspects of observations possible with 1.50 m-class telescope, the CDROM with the contributions was printed. The second BELISSIMA Workshop is scheduled for the spring of 2013 when the local astronomical community will discuss the feasible projects with the "Milanković" telescope. The international BELISSIMA conference, "Future Science With Metre-Class Telescope" was held in Belgrade in September 2012 and approximately 100 participants took part in it and the present Proceedings books will serve as a useful source of information for the observing projects which will use the "Milanković" telescope. Whenever possible the participants of BELISSIMA took part in various initiatives to promote the project and the activities of the AOB. Here we mention AIS^3 (Association of Italian and Serbian Scientists and Scholars) organized by Paolo Battinelli, astronomer from Rome, presently attaché for science with the Italian embassy (see his contribution in these Proceedings): both the AOB and BELISSIMA were presented at the AIS^3 Workshop "Serbia-Italia: Status and Perspectives of Scientific and Technological Bilateral Cooperation", held in June 2012 in Belgrade (Samurović & Knežević 2013). We also mention the presentation of the BELISSIMA project at the 16th National Conference of the Astronomers of Serbia held in October 2011 (see Samurović 2012b).

2. 5. WP5. PROJECT MANAGEMENT

The project management of the BELISSIMA project was done by the Management board of the project and coordinated by S. Samurović. The Management board includes all the leaders of WPs (as given above) and had meetings on a regular basis when the activities of the project were discussed and the tasks for a future work were created.

3. CONCLUSIONS

In this contribution the most important facts regarding the BELISSIMA projects and its activities were presented.

The BELISSIMA project proved to be important for Serbian science. It created favourable conditions for the return of Serbian researchers working abroad and three astronomers initiated their professional careers at the AOB. By constructing the "Milanković" telescope Serbia is opening doors to the new technologies in the field of optics, astronomy, informatics, and electronics. The BELISSIMA project played an important role in improving scientific literacy in Serbia and its products (such as TV programs, these Proceedings, the AOB brochure, etc) are expected to provide useful information to the professional community and interested public. The hiring of three experienced researchers at the AOB will intensify the research efforts performed at one of Serbia's most distinguished research institutes. BELISSIMA strengthened and established new regional collaborations with partners from the Western Balkans and with the leading European scientific institutions. The BELISSIMA WWW site is at `http://belissima.aob.rs` and will remain active after the end of the project (July 2013) providing information and multimedia content.

ACKNOWLEDGEMENTS. This project was made possible through support provided by the European Commission through BELISSIMA (BELgrade Initiative for Space Science, Instrumentation and Modelling in Astrophysics, call FP7-REGPOT-2010-5, contract no. 256772). We also acknowledge the support from the Ministry of Education, Science and Technological Development of the Republic of Serbia through project no. 176021 "Visible and Invisible Matter in Nearby Galaxies: Theory and Observations".

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Metre-Class Telescopes and Instruments

Publ. Astron. Obs. Belgrade No. 92 (2013), 19 - 20 *Invited lecture*

CAN SMALL BEAT THE BIG?

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Abstract. Large telescopes (4 m diameter apertures and bigger) are relatively few in number and getting observing time on them is highly competitive. On the other hand, there exists an army of productive 1-2 m class telescopes at fairly good observing sites. An affordable laser guide star Adaptive Optics (AO) system on these small telescopes which offer good sky coverage, diffraction limited imaging and robotic operation will open up exciting new observational possibilities such large surveys, rapid follow ups etc. In this talk I will share the experience with the concept, design, development and deployment of such an AO system.

Presentation link:
`http://belissima.aob.rs/Conf2012/Ramaprakash_2012.pptx`

Publ. Astron. Obs. Belgrade No. 92 (2013), 21 - 26 *Contributed paper*

THE STELLA ROBOTIC OBSERVATORY ON TENERIFE

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Abstract. The STELLA project is made up of two 1.2 m robotic telescopes to simultaneously monitor stellar activity using a high-resolution spectrograph on one telescope, and an imaging instrument on the other telescope. The STELLA Échelle spectrograph (SES) along with the building has been in operation successfully since 2006, and is producing spectra covering the visual wavelength range between 390 and 870 nm at a spectral resolution of 55 000. The stability of the spectrograph over the entire two year span, measured by monitoring 15 radial velocity standard stars, is 30 to 150 m/s rms. The Wide-field stellar imager and photometer (WIFSIP) was put into operation in 2010, when the SES-lightfeed was physically moved to the second telescope. We will give an overview of the main scientific topics of the bulk of the observing programs.

1. INTRODUCTION

STELLA (short for STELLar Activity) is a fully autonomous observatory located at Teide observatory on Tenerife, Spain. The Teide observatory is located in the vicinity of Teide peak at Izaña, longitude 16°30′35"W and at latitude 28°18′00"N at an altitude of 2390m above sea level. STELLA consists of two independent, 1.2m telescopes, each of them serving a single instrument to avoid the necessity of instrument change. Both telescope have been manufactured by Halfmann Telescope in Augsburg, Germany and are modern az-alt telescopes with a maximum slewing speed of 10°/s. The observatory housing was finished in spring 2002, well before the telescopes have been delivered. It consists of two roll-off roof-halves, which are driven by standard industry crane motors. The early completion of the building left ample time for testing the reliability of building operation which main focus is a reliable protection of the instruments during bad weather periods. The meteorological observing conditions are measured by two separate weather stations. So far, the building automation has never failed to protect the instruments during harsh weather phases. All of the algorithms developed in the beginning are still in place unchanged, the only addition to the meteorological system has been the addition of a dust meter to allow the detection of low-altitude Sahara dust, a rather common phenomenon on the Canaries known as *Calima*.

The Stella-I telescope, which is an f/8 Cassegrain system with two available Nasmyth ports, has been delivered in the end of 2004. This telescope is optimized for wide field-imaging with an field-of-view of 24 arc minutes, but was originally feeding the STELLA Échelle Spectrograph (SES), an échelle spectrograph with a spectral resolution of 55 000 and a simultaneous wavelength coverage from 390 to 870 nm, which achieved first light on this telescope in September 2005. An acquisition and guiding until was constructed for the fixed Nasmyth port, which held the fiber input to the spectrograph, a focus pyramid and a gray beam-splitter to divert 4% of the light to a small, uncooled KAF-0402 detector system (Strassmeier et al. 2004).

In late 2005, the second telescope, STELLA-II has been delivered. STELLA-II is equipped with only one f/8.4 focus at the top ring, where a refracting corrector

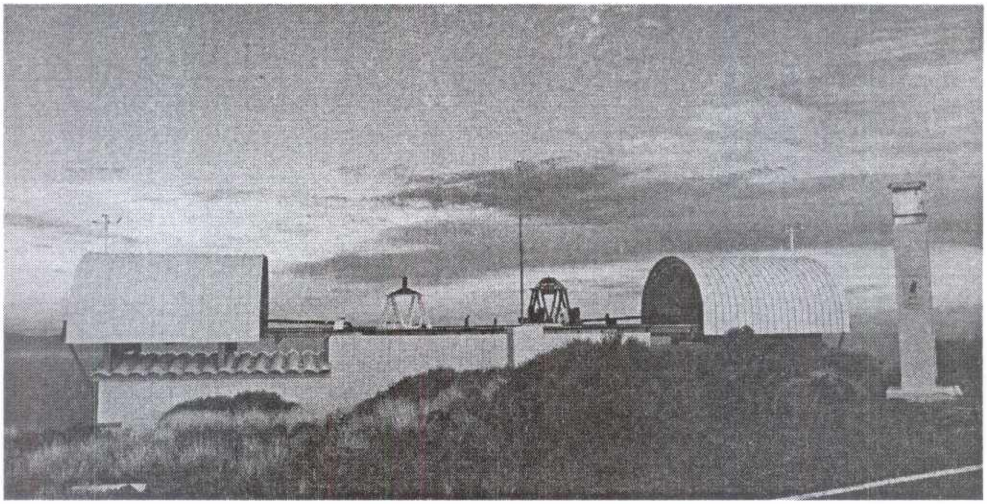

Figure 1: View of the STELLA building just after sunset, the roof is rolled off to the sides of the building. The STELLA-I telescope is located at the right (West) side of the building and is open for sky flat fields, the STELLA-2 telescope is located at the left (East side). Also visible at the right edge is the ASIVA, an infrared cloud monitor, located on it own column about 20m from the main building.

system corrects the light from the spherical primary for a field of approximately one arc minute. The light enters the 50μm fiber in a small unit which also houses an optics wheel with as set of fixed atmospheric dispersion correctors, a small focussing unit and a acquisition camera which is also used for guiding on the residual light reflected from the inclined, reflective pinhole.

The formal opening of the observatory took place in May 2006, and the SES science demonstration program was started soon thereafter. The second instrument, the wide-field imaging photometer WiFSIP (Wide Field Stella Imaging Photometer) was completed in 2009. It underwent testing on our 80cm sister telescope of STELLA-I, RoboTel, located at the AIP campus in Babelsberg. This telescope is now equipped with another WiFSIP copy. WiFSIP features in brief:

- 4k×4k ITL chip with 15μm pixel and support four-amplifiers readout.
- The usable field-of-view is 22 arc-minutes squared.
- Johnson UBV$(RI)_C$, Sloan u'g'r'i'z' filters, and a full Strømgren set uvby including H_β wide and narrow.
- H_α photometry with a wide (FWHM=18nm) and a narrow filter (FWHM=3nm).

WiFSIP was delivered to Tenerife in 2010, where it was mounted on STELLA-I. At the same time, the spectrograph input fiber was moved over to STELLA-II achieving 'second first light' in May 2010. Since then, both telescopes are operating, but a few necessary updates are still ongoing: the spectrograph gets a more efficient optical camera, a larger CCD detector system and a modified fiber feed, while the CCD

Figure 2: Example SOCS data: a single image of NGC 7092, exposure time 40 s in Sloan r'. We use this passband to derive rotational periods.

detector system of WiFSIP will be replaced with a similar device with better cosmetics and therefore better flat-field accuracy.

2. STELLA/WiFSIP

Due to tight space restrictions, STELLA-I could not be equipped with an off-axis guiding system, which was originally anticipated to fit to the side of the main WiFSIP camera. Instead, a piggy-back mounted auxiliary telescope is used for acquisition and guiding. This auxiliary telescope is a 15cm refracting telescope equipped with a KAF-3200 detector. Differential bending between main and auxiliary telescopes amounts to 136 arc seconds in elevation between horizontal and vertical pointing. A differential pointing model to compensate for this differential bending was derived with an original RMS of 2 arc seconds. Disappointingly, it degraded after half a year to currently roughly 45 arc seconds RMS. This is acceptable for short exposure times up to 25 minutes, depending on pointing direction, but rules out very long exposures.

The current calibration scheme relies on sky-flats, but the installation of an illumination panel inside the dome is being investigated. A smaller version, consisting mainly of an illumination foil, is being tested at the RoboTel telescope in Potsdam. During each twilight, three filters can be measured at ten exposures each. With a total of 18 filters, this allows for repeated observations of flat field with an average cycle

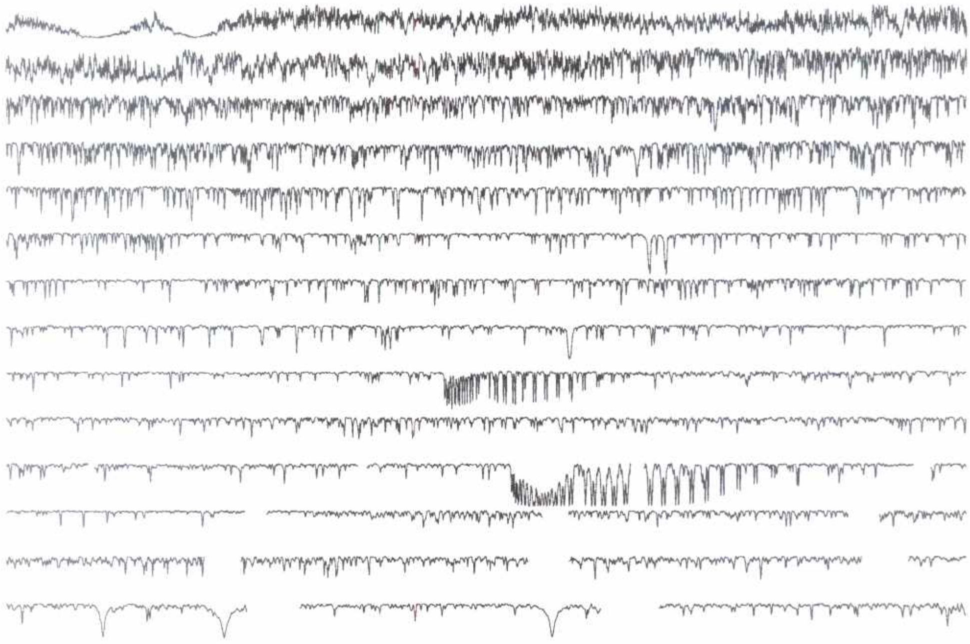

Figure 3: Example SES data: a full spectrum of HD 1. The wavelength coverage is from 390 to 870 nm, the gaps towards the red end of the spectrum are due to the comparably small format CCD detector in use until 2012.

period of three days. Prior to the twilight flat, a number of bias and dark frames are obtained. Regular science frames start at an sun height of −14°, but non-standard observations (time critical or targets of opportunity) may commence at any time the sun is at least 6° below the horizon. Since first light more than 188000 science frames have been obtained as of Februar 28, 2013.

The first science program, a monitoring program on open stellar clusters is not affected by guiding errors due to the rather short exposure times. Figure 2 shows a full-frame exposure of one of the target clusters, NGC 7092. The image was taken in Sloan r' at an exposure time of 40sec. More than 7000 sources have been detected in this frame, at an average FWHM of 1.3 arc seconds.

2. 1. WIFSIP CORE SCIENCE

The main advantage of the STELLA robotic telescopes is the time domain, since tasks can be defined in a very general way without the need to squeeze the observations in a short time-window. It is was therefore a logical step to combine Stellar Activity and Time series in the core science program of STELLA/WiFSIP, which is the STELLA open cluster survey (SOCS). The main goals of this programs are:

- Rotational Periods of open cluster stars.
- Age sequence of clusters delivers $\Delta P/\Delta t$.

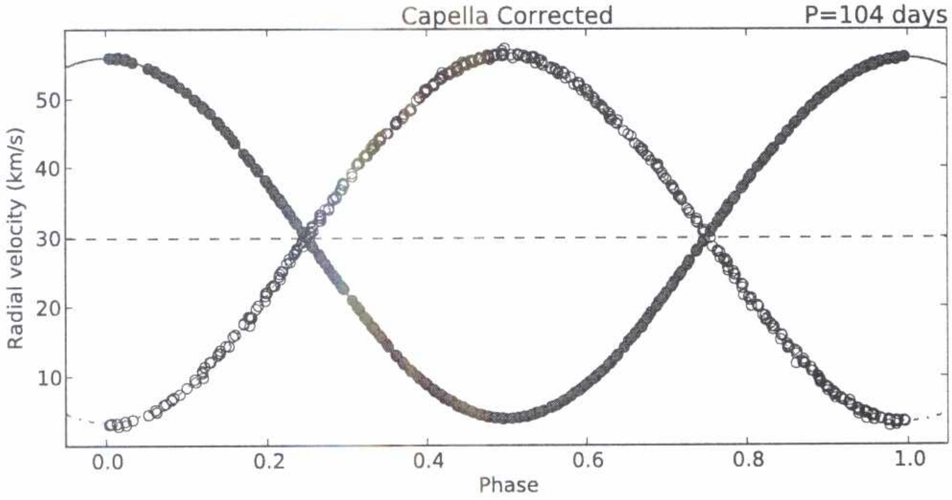

Figure 4: Example SES radial velocity data: we observed Capella for several years to improve the orbital parameters, namely the mass-ratio of the two components.

To achieve this, a cluster age-sequence is observed in a single filter many times to derive the stellar rotation periods, and is observed once in Strømgren filters to derive physical parameters of the cluster member stars. Besides this core-science program, general proposals like planetary transits and gamma-ray burst follow-ups are observed.

3. STELLA/SES

SES is a bench-mounted, white-pupil spectrograph with a fixed wavelength range of 390-870 nm obtained during a single exposure (Weber et al. 2008). Figure 3 shows a spectrum of HD 1, an object observed during the science-verification phase Strassmeier et al. 2010). SES is fed with a 50μm fiber, allowing for a resolution of R=$\Delta\lambda/\lambda = 55000$. For stability, it is located in a temperature controlled environment in a separate room below the telescope bay. Heat foils on the walls and below the spectrograph cover allow us to keep the temperature on the optical table at an average of 19.6°C, with an RMS of 0.68°C, which is a little bit higher than the anticipated 0.5°C, but still allows radial-velocity determination with a long-term error down to $\approx$50m/s (see Weber & Strassmeier 2011).

The calibration sequence on the spectroscopic instrument starts with a single Thorium-Argon spectrum, followed by a block of 20 bias exposures. Then, another Thorium-Argon spectrum follows. Flat-field is then calibrated by obtaining 60 single exposures. Finally, just before the roof opens, another Thorium-Argon spectrum is obtained. Calibrations are done with dedicated halogen or Thorium-Argon lamps. In total four lamps are present to allow on-the-fly replacement if one burns out. The proper calibration lamp is selected with a linear stage in a light-tight calibration box residing in the main electronics room of the observatory. Its light is fed with a 200μm calibration fiber up to the science fiber entrance at the telescope's AG-unit.

Acquiring on the target star is a two-staged process. A piggy-back telescope identically to the one on STELLA-I is used to raw-acquire the target star. Within the fiber unit of STELLA-II, a small industrial firewire (Unibrain-520b) fiber-viewing camera is used. This camera features a 640×480 pixel progressive scan CCD at a pixel size of 7.4 μm. It has a tunable exposure time from 1 μsec. up to 65 sec., which allows acquiring and guiding of stars from 0^{m} down to 14^{m}. After the coarse acquire with the auxiliary telescope has completed, the fiber viewing camera takes over. Its field-of-view spans roughly 2×1.5 arc minutes, enough to accommodate differential bending effects between the main and the auxiliary telescope. Guiding is done on the light spilled over at the fiber entrance using a simple center-of-gravity method. Since first light, we obtained more than 37000 science spectra.

3. 1. SES CORE SCIENCE

The core-science of SES is time-series Doppler Imaging. This is the science application the observatory and its scheduling system was designed for. Our interest is to monitor changes of stellar activity on stars comparable to the global solar sunspot cycles (which lasts about 11 years) or the decay rates of starspots.

Since this core-science program is very demanding for the scheduler due to the phase-coverage needed for Doppler imaging, only a moderate share of the available time is used by this program. During the remaining time, a wide range of programs are carried out. We observed a number of active stars to obtain updated or new orbital parameters in case they were binaries (Strassmeier et al. 2012), for example. Further examples are revised orbital parameters of Capella (Fig. 4, Weber & Strassmeier 2011), and high-resolution spectra contemporary to FORS-observations of FK Com (Korhonen 2009).

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Publ. Astron. Obs. Belgrade No. 92 (2013), 27 - 28 *Contributed paper*

SMALL IS BEAUTIFUL - EXPERIENCE AND PLANS OF THE TARTU OBSERVATORY

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Abstract. We briefly review our experience of collecting long-term spectroscopic time-series for variable stars on the 1.5-meter telescope, and our expectations after recent renovation of the telescope control system. Also, benefits expected of the new 0.3-meter robotic telescope, which will be mounted soon, will be briefly described.

Presentation link: `http://belissima.aob.rs/Conf2012/Leedjarv_2012.ppt`

Publ. Astron. Obs. Belgrade No. 92 (2013), 29 - 30 *Contributed paper*

ASTRONOMICAL FOURIER TRANSFORM SPECTROSCOPY AT THE HAMBURG OBSERVATORY

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Abstract. Recent advances in detector development have enabled techniques such as Imaging FTS and Post Dispersion, making Fourier Transform Spectroscopy competitive again for certain astronomical applications dominated by Echelle Spectroscopy during the last decades. At the Hamburg Observatory we are developing several of these techniques for both Stellar and Solar Spectroscopy.

Presentation link: `http://belissima.aob.rs/Conf2012/Perdelwitz_2012.pdf`

Publ. Astron. Obs. Belgrade No. 92 (2013), 31 - 38 *Contributed paper*

VIDOJEVICA PROGRESS REPORT 2012

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Abstract. We present an overview of our results on the development of the Astronomical Station Vidojevica (ASV) site in 2012. After a period of infrastructure development, instrument installation and testing, the 60 cm telescope is now regularly performing science observations for three projects from Astronomical observatory in Belgrade. We describe our other scientific activities, student training sessions and educational seminars held in 2011 and 2012. We also present the status of design and acquisition of the new 1.5 m-class robotic telescope "Milanković".

1. INTRODUCTION

The Astronomical Observatory of Belgrade (AOB) has performed preliminary investigations towards identifying a new observatory site, away from its current location in Belgrade, since the early 1980's. One complete issue of the Publications of the Astronomical Observatory of Belgrade, entitled "Astroclimatic explorations for site selection of the high altitude station of the Belgrade Observatory" has been devoted to investigations of the candidate sites (see Arsenijević et al., 1981 and other references in the same volume). The peak of Mt. Vidojevica (elevation 1155 m asl.) near Prokuplje has been considered favorable for a new astronomical station based on these works. The interest in the site gained momentum around the year 2000 with an initiative at the Department of Astronomy, Faculty of Mathematics, University of Belgrade, which led to the start of construction of the Astronomical Station Vidojevica (ASV) in 2003 (Ninković et al., 2007). Some basic local climate investigations have been attempted in Mijajlović, 2006 and Jovanović, 2012.

However, the installation of the first telescope at the ASV site, the 60 cm Cassegrain, started only in the Fall of 2010. In the past two years, supporting infrastructure at the site has been completed, including Internet connection, installation of an automated meteorological station, all-sky camera and a seeing monitor. A number of upgrades to the original design of the dome and building were also proven necessary. For example a separate warm observing room (prefabricated container) has been added in the Fall of 2011 and it now contains all the computer and supporting electronic equipment necessary for the operations of the telescope. The dome rotation motors and controls were redesigned in 2012 in order to allow for integration in with the telescope control system. Finally, a system containing temperature sensors, humidity sensors and hardware limit switches for the telescope itself was designed and installed in 2012 as well.

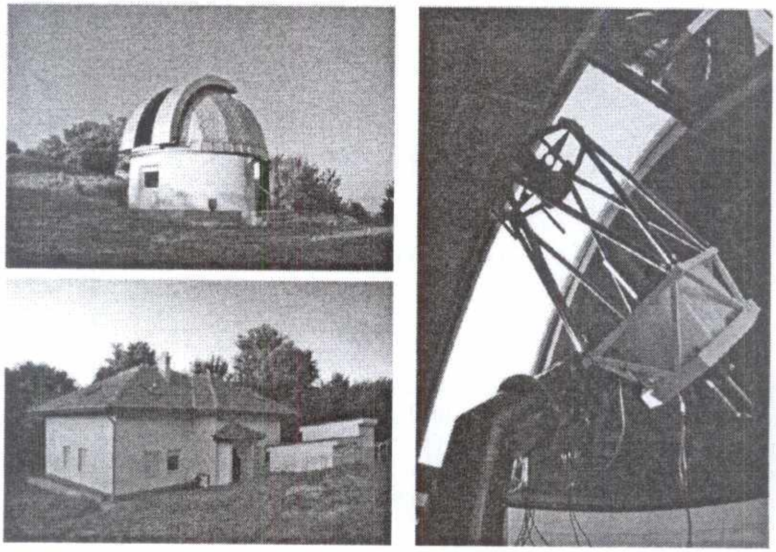

Figure 1: The infrastructure at Astronomical Station Vidojevica and the 60 cm telescope. Top left: the dome building for the 60 cm telescope. Bottom left: the lodging building. Right: the 60 cm telescope, manufactured by Astro Optik.

2. ASV SCIENCE OBSERVATIONS IN 2011 AND 2012

Since the second half of 2011 the 60 cm telescope at ASV has been operational in a "shared-risk" mode, during which the telescope has been tested and supporting infrastructure, software and hardware for the instruments and automated dome operation were still in some development. Some results of the telescope and instruments testing have been published during 2012 (Cvetković et al. 2012, Vince and Jurković 2012, Stojanović et al. 2012, Vince 2012).

First astrometric observations of asteroids in the Solar system from ASV have been performed in November 2011 (Bogosavljević and Smolić, 2011). After verification of the precision achieved, Minor Planet Center (MPC) of the IAU has included ASV in its list of observatories that are eligible to report measurements for positions of moving bodies. The observatory code assigned by MPC for ASV is C89. To our knowledge this is only the second permanent observatory facility (of any size) in Serbia registered with the MPC, the first one being the AOB itself with code 057.

The winter of 2011/2012 was exceptionally severe in Serbia. As a result of unusually heavy snowfall, the site itself was inaccessible for a period of more than two months. Regular activities at ASV resumed only in March 2012.

In 2012, three science projects from AOB were assigned regular observing time slots and corresponding observations were performed at ASV:

- Photometric light curves of close binary systems (PI Gojko Djurašević),

- Orbits of visual binary star systems (PI Rade Pavlović),
- Optical observations of reference extragalactic radio sources (PI Goran Damljanović).

In addition, ASV has participated in its first international collaborative observing campaign in June 2012. Christopher Mauche from Lawrence Livermore National Laboratory and colleagues from Spain and Oman have requested observations in support of a multiwavelength observational campaign[1] of object AE Aqr, and intermediate polar cataclysmic variable. The 60 cm telescope at ASV took part by providing optical B-band photometry taken during nights of June 14 - 18 (Figure 2.) in synchronization with observations taken by Swift satellite, MAGIC Cherenkov telescope on La Palma and 0.6 m KVA (La Palma) and 1.3 m Skinakas (Crete) optical telescopes (Ioannou, these proceedings).

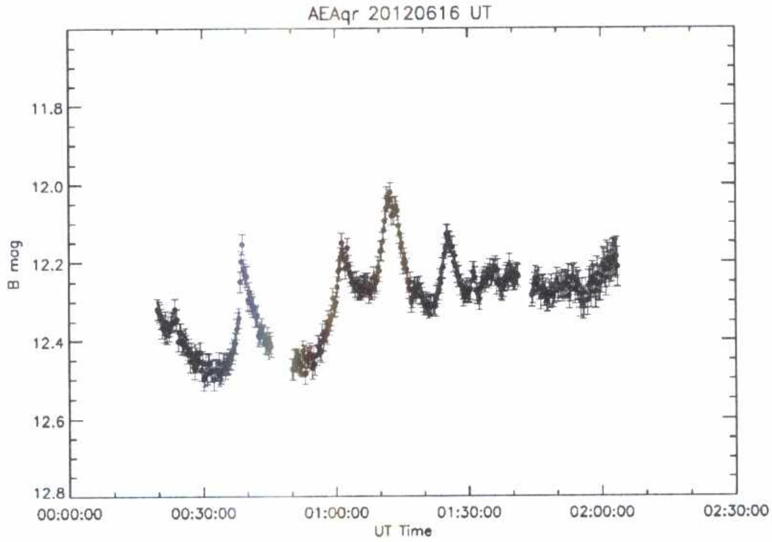

Figure 2: An example of AE Aqr photometry in B-band, taken with 60 cm telescope at ASV. The brightness of the object was measured at roughly 14 second intervals using Alta Apogee U42 CCD camera.

Due to two very long interruptions caused by the technical problems we have experienced with the telescope and dome in summer of 2012, the total time spent observing on-source in 2012 was only about 40 nights. However, after overcoming these initial difficulties, we expect that in 2013 we will be able to utilize most of clear nights at ASV. At the time of writing of this contribution, the 60 cm telescope is capable of operating in a remote observer mode, with the observer controlling the telescope in real-time via the Internet. The telescope dome tracks the position of the telescope automatically, though the opening and closing of the dome still must be performed manually. We will continue the upgrade of the telescope dome to enable

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[1] `http://www.aavso.org/aavso-alert-notice-458`

a full remote and robotic operation (e.g. scheduled observations) with the 60 cm telescope in the near future. This will drastically increase the effective on-source time we can achieve with the 60 cm telescope.

3. EDUCATION AT ASV IN 2011 AND 2012

Educational activities in astronomy are considered an integral part of the role of ASV in Serbia. The observatory site does not yet have the resources and staff to handle interested visitors on a daily basis, however, special seminars for groups of up to 50 people can be organized with the help of AOB staff and University lecturers. Below we will describe our educational activities in the past year, presented in chronological order.

While still in the early phase of testing operations with the 60 cm telescope, the ASV has taken part in the SEENET-MTP seminar series of lectures, during the Balkan Summer Institute 2011 (BSI[2]). The part of the BSI seminar at ASV (August 19-21, 2011), was jointly organized by SEENET-MTP Network and its Office at the Faculty of Science and Mathematics Niš, Physical Society Nis in cooperation with UNESCO Venice Office, Faculty of Physics University of Craiova and Astronomical Observatory Belgrade (Project BELISSIMA). Two lectures were presented during the course of a half-day visit to the ASV site: one about ASV in general and the other about Astronomy via the Internet (lecturers O. Vince and M. Bogosavljević). The audience of about 50 participants, comprised for the most part of physics teachers and university faculty, also made a brief visit to the 60 cm telescope where a presentation about its operations was given.

In October 2011 the ASV took an active part in the course of a science project for high-school students. The project was named MONECOM and a poster about the project was presented during the course of the "Future science with metre-class telescopes" conference (Bogdanović et al., these proceedings). The aim of the projects was to perform photometric observations of several Main Belt Comets with the 1.2 m MONET North telescope (Hessman 2007, Bischoff et al 2006). A collaboration of schools from Croatia, Greece and Serbia was created for the six nights of the observational campaign and latter data analysis. The students were supervised by their teachers and local astronomers. The group of students from Serbia received preliminary training in observational techniques at the ASV 60 cm telescope, and performed remote observations with MONET/North from ASV site on October 28th and 30th, 2011. For more information and the results, we refer the reader to the poster Bogdanović et al. in these proceedings.

Lastly, the first training session for undergraduate students of astronomy and astrophysics from University of Belgrade and University of Novi Sad was held at ASV (June 16-18, 2012). The students at ASV have attended several presentations on topics of importance for observing with optical telescopes and CCD cameras. The lecturers were Tijana Prodanović from the Physics Department, University of Novi Sad, Dragana Ilić from Department of Astronomy, University of Belgrade and Milan Bogosavljević from AOB. With the ASV 60 cm telescope the students performed CCD photometry of optical transient sources reported by the *Astronomer's Telegram* (Rutledge, 1998) and *Skyalert.org* (Williams et al, 2009). This observing session was

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[2] `http://bsw2011.seenet-mtp.info/`

the first in what is to become a yearly event of student practice sessions with the 60 cm telescope at Vidojevica.

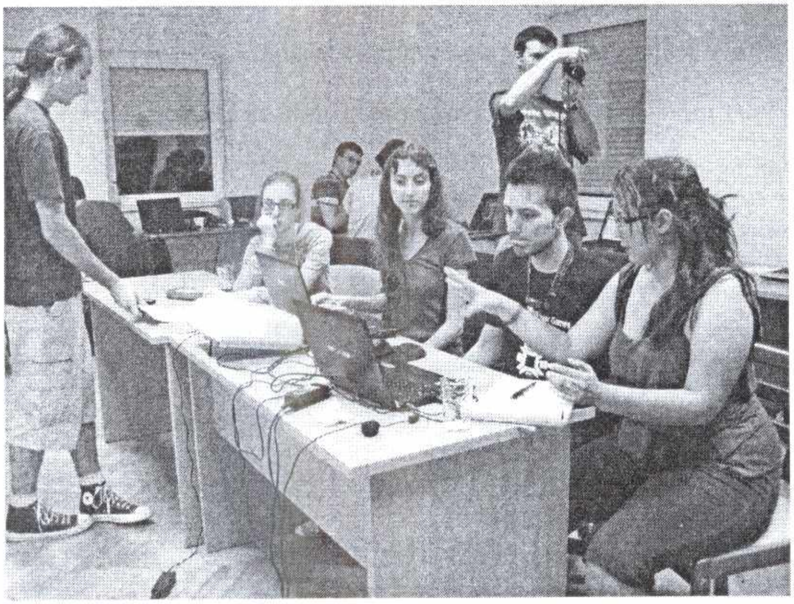

Figure 3: Undergraduate students during a training session at ASV in June 2012.

4. MOVING ON TO PHASE II: THE 1.5 m-class TELESCOPE

The plans for Phase II of the site development include a construction of what would be the main instrument of ASV site, a 1.5 m-class optical telescope "Milanković". The purchase of the new telescope has been supported by grants from the European Commission (project BELISSIMA) and Ministry of Education, Science and Technological development of the Republic of Serbia.

The purpose of the new telescope is to bring back AOB to the forefront of observational astronomy in the region of Western Balkans. The cost constraints have set constraints to proceed with a common and simple telescope design for photometry and low-resolution spectroscopy, but with capability of full autonomous robotic operation.

Some key features of the telescope are:

- Primary mirror diameter 1.5 m-class (depending on cost),
- Field of View 30 arcmin,
- Focal length f/8 (12 meters),
- Nasmyth and/or Cassegrain foci,
- One CCD and one low-res spectrograph permanently mounted.

The time allocation strategy for the telescope "Milanković" has been envisioned to include the following applications, with provisional percentages of allocated time given here:

- AOB key science projects (about 50% of time),
- Collaborative long-term campaign (about 30% of time),
- Training of students (10%),
- Follow-up of optical transients (Targets of opportunity) (5%),
- Instrument development / testing (5%).

The envisioned modes of operation of the telescope include direct on-site observing, full remote control in real time over the Internet and fully robotic queue-scheduled observations. The real-time status of the telescope would be available on-line to the community for short-response observation requests. Our long-term goal is to integrate the 1.5 m telescope (and its instruments, with automated data reduction) within a large network of robotic telescopes.

Currently the instruments at ASV are maintained by AOB staff (traveling to site). As the project develops with the construction of the 1.5 m telescope, our staff will eventually have to include a local technical daytime crew and public relations personnel for organized visits and lectures for the public.

The process of the telescope design, purchase and installation has experienced significant delays due to the local political instability in Serbia in 2011 and 2012. Eventually the co-financing by the government of Serbia has been secured for the new instrument, whereas the financing for the infrastructure is still not resolved. The initial plan was for the telescope to be installed by the end of 2013, however, our current best estimate envisions the telescope on site by the mid-2015.

5. CONCLUSIONS

The activities at Astronomical Station at Vidojevica since the Fall of 2011 have been described. After a period of work on improving the infrastructure at ASV and installing and testing of the instrument, three science projects from AOB have been regularly using the 60 cm telescope for their science observations. The 60 cm telescope has been registered with Minor Planet Center as observatory C89. In June 2012, the ASV took part in its first international observing campaign in June 2012, providing observations of cataclysmic variable AE Aqr in synchronization with other optical observatories, Swift satellite and MAGIC Cherenkov telescope on La Palma.

Due to a number of interruptions in operations and technical problems, all projects have been able to observe on only about 40 nights in total in 2012. However, a lot of effort has been invested in improving the infrastructure at ASV in order to enable remote observing sessions with the 60 cm telescope, which should increase the observing time which is efficiently used.

There have been a number of activities at ASV related to education and student training. The ASV took part in Balkan Summer Institute 2011, MONECOM project for high-school students and hosted the first training session in observational astronomy for undergraduate students from University of Belgrade and University of Novi Sad.

The next phase of the development of ASV is the construction of what is to become its main instrument, a 1.5 m class robotic telescope. We describe the plans for the telescope design, modes of operation and time allocation strategy. After experiencing significant delays, due to the problems with co-financing by the government of Serbia, the current best estimate is that the telescope "Milanković" will be installed on site by the mid-2015.

ACKNOWLEDGEMENTS. This work was supported by the European Commission through project BELISSIMA (BELgrade Initiative for Space Science, Instrumentation and Modelling in Astrophysics), FP7-REGPOT-2010-5 grant agreement no. 256772. We also acknowledge the support from the Ministry of Education and Science of Republic of Serbia through project no. 176021 "Visible and Invisible Matter in Nearby Galaxies: Theory and Observations".

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Publ. Astron. Obs. Belgrade No. 92 (2013), 39 - 40 *Invited lecture*

SONG IS STARTING TO SING

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Abstract. Stellar Observations Network Group is an initiative to design and build a global network of 1 m telescopes dedicated to asteroseismology and exoplanet hunting. I will describe the layout of the instrumentation and the building of prototype node. The first results of the commissioning will be presented.

Presentation link: `http://belissima.aob.rs/Conf2012/Grundahl_2012.pdf`

Publ. Astron. Obs. Belgrade No. 92 (2013), 41 - 46 *Contributed paper*

AN ECHELLE SPECTROGRAPH
FOR THE MILANKOVIĆ TELESCOPE

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Abstract. In this paper we report some general outlines on a construction of a high resolution échelle spectrograph, which we propose to build for our future 1.5-m class Milanković Telescope (**MIL**anković **E**chelle **S**pectrograph - MILES). MILES would be a mechanically stabilised and temperature controlled high-resolution ($R \sim 50000$) fibre-fed spectrograph for visible and near infrared wavelength region of electromagnetic radiation. Here, a white-pupil optical design of the spectrograph is described and the main optical and mechanical elements are discussed. The set of these elements includes: an optical fibre for a link between the telescope and the spectrograph entrance slit, an échelle grating, the collimator and camera optics, the cross-disperser prisms, a CCD detector and an optical table. Since we plan to build MILES from commercially available elements, it has been possible to estimate its price, which amounts to about 550 kEU.

1. INTRODUCTION

The motivation for planning a high-resolution spectrograph is based on achievements of the second work-package (WP2) of the Belissima project [1] financed by the European Commission under the FP7 REGPOT and operated at the Astronomical Observatory of Belgrade since 2010. The main goal of WP2 has been the acquisition of a 1.5-m class telescope. This project was seriously progressed in the last period and the telescope optical design was almost completely defined. The optical parameters of the telescope necessary for planning and designing any astronomical instruments to be attached to it are known. The atmospheric parameters relevant for astronomy, such as the seeing conditions, humidity, cloudiness, wind speed and direction are also known, owing to an automated whether station, a seeing monitor and a 60-cm telescope that have been regularly operated at the telescope site (Vidojevica mountain) for two years. Therefore, we have access to all necessary information required for designing an astronomical instrument for the Milanković telescope. In this paper we present an optical design for a high spectral resolution and mechanically and thermally controlled échelle spectrograph.

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[1] `http://belissima.aob.rs/`

2. THE TELESCOPE CHARACTERISTICS

According to our Technical Description incorporated into the Bidding Documentation for purchasing a 1.5-m class research grade astronomical telescope for the Astronomical Station Vidojevica (ASV) the main telescope parameters that have the most crucial influence on its scientific capability are as follows:

- primary mirror effective aperture: $1.35\ \mathrm{m} \leq d_{\mathrm{eff}} \leq 1.40\ \mathrm{m}$,
- two or more ("bent") Cassegrain focal stations, or a combination of Nasmyth and Cassegrain foci,
- effective optical system focal ratio: $7.0 \leq N \leq 9.0$,
- encircled energy (EE) value of 80%, or better, within a diameter of 0.5 arcsec for on-axis measurements, and EE value of 80%, or better, within 0.7 arcsec for off-axis measurements,
- tracking accuracy (without auto-guider correction) of ≤ 0.5 arcsec RMS over a time period of at least 600 seconds.

3. THE CHARACTERISTICS OF THE LOCATION

The new telescope will be installed at the Astronomical Station Vidojevica, located on the summit of the mountain Vidojevica, about 20 km from the town of Prokuplje, in southern part of Serbia. The main site characteristics are as follows:

- Astronomical Station Vidojevica coordinates:

  geographic latitude: $43^\circ\ 8'\ 28''$ N,
  geographic longitude: $21^\circ\ 33'\ 20''$ E,
  altitude: 1155 meters above sea level,

- Meteorological characteristics:

  common yearly temperature range: from -20 to $+35$ degrees Celsius, relative humidity range: from 30% up to 100%, mean 70%.

- Atmospheric seeing: 1.3 arcsec (median, at zenith).

4. RATIONALES

Since the 1.5-m class Milanković telescope will be operated by the Astronomical Observatory of Belgrade, it will guarantee a long and secured access for observers, which is ideal for dedicated monitoring programmes of variable phenomena.

Telescopes of $\sim$ 1.5-m objective diameter are ideal for high spectral resolution ($R \sim 50000$) observations of celestial objects with available large grating sizes ($\sim$ 50 cm) and seeing conditions ($\sim 1.5''$) at Astronomical Station Vidojevica (ASV). Therefore, we plan to use the telescope for collecting high-quality time series of high-resolution spectra. Based on our prior experience with various spectra taken for line profile analysis of solar like stars and radial velocity measurements of close binary stars, we propose for the Milanković telescope a high-resolution, fibre-fed, gravity-invariant, thermally-controlled échelle spectrograph (MILES) with a white pupil optical design, similar to some existing large astronomical spectrographs (Raskin et al. 2011).

5. GENERAL OPTICAL LAYOUT

A simplified diagram of a fibre-fed échelle spectrograph is shown in Figure 1. The optical fibre entrance is located in the focus of a telescope with the aperture diameter D and focal length F, so that the focal ratio of the input cone is $N = F/D$. For the sake of simplicity, the picture does not show the actual optical system which reduces the focal ratio to a value of about $N = 4$ suitable for the optical fibre. The fibre has a diameter s and transfers the light to the other end. We will neglect here the effect of the focal ratio degradation (FRD) in the optical fibre and assume that the light emerges at the same focal ratio N. In reality, this will only be slightly degraded, perhaps to about $N \approx 3.75$.

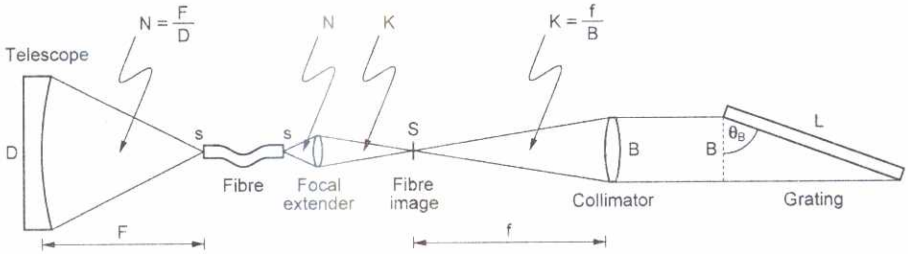

Figure 1: Main elements of a fibre-fed échelle spectrograph. Only the parts affecting the resolving power are included. The cross-disperser and the camera are not shown.

If the collimated beam illuminates an échelle grating at the blaze angle (Littrow configuration), the resolving power is:

$$R = \frac{2NB\tan\theta_{\rm B}}{s}.$$

It is obvious from this equation that the resolving power does not depend on any focal extension used at the fibre exit. It depends only on the fibre diameter s, original focal ratio N, collimated beam diameter B, and the blaze angle $\theta_{\rm B}$. By using a grating with a steep blaze angle of 76° ($\tan\theta_{\rm B} = 4$), and assuming that the focal ratio N is around 3.75 (including the degradation), we find that a relatively small diameter of the collimated beam of $B = 100$ mm can be sufficient for high resolving powers. In this case, the formula for R becomes $R = 3000000/s$, where s is in micrometres. With a 50-μm fibre, the resolving power is 60000. With a 75-μm fibre, we have $R = 40000$, which is still high enough for most spectroscopic applications in astronomy. The expression for R can also be rearranged as:

$$R = \frac{2L\sin\theta_{\rm B}}{\theta_{\rm s}D},$$

where $\theta_s = s/F$ is the angular size of the fibre entrance projected onto the sky, D is the diameter of the telescope, and L is the length of the grating. Since θ_s is determined by the atmospheric seeing, which at ASV, for zenith angles 0–45°, in average amounts to about 2–3 arcsec, it is obvious that in order to maintain a resolving power of about 50000 a telescope of 1.5-m aperture requires a 40-cm grating with a blaze angle of 75°.

6. Optical design

Our fibre-fed échelle spectrograph is based on a white-pupil design, which offers a significant reduction in the size (and cost) of all optical elements, while maintaining a high resolving power. This is achieved by redirecting the diffracted beams from the échelle grating back into one white pupil of the same diameter as the original collimated beam. A schematic diagram of a spectrograph based on a white-pupil design is shown in Figure 2. This particular design uses two parabolic mirrors as collimators. The input cone of diverging light from the optical fibre is sent to the first collimator (on the right). The collimated beam illuminates the échelle grating and is dispersed back into a fan of beams depending on the wavelength. The diffracted beams fall onto the collimator again (second pass) and are focused at the focal plane of the parabola. The light rays then pass trough the focal plane as a fan of diverging beams directed at the lower part of the second collimator (on the left) where they are reflected, collimated again, and directed towards the cross disperser (a pair of prisms). The re-collimated beams of different wavelengths, when they fall on the cross disperser, form a single white circle of light of the same diameter as the input collimated beam.

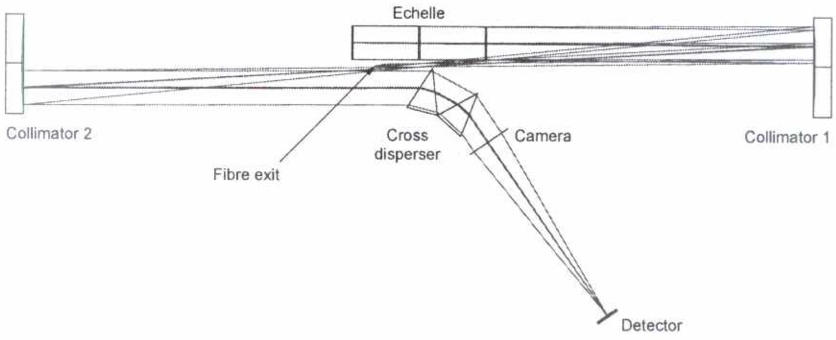

Figure 2: Proposed optical design of the MILES spectrograph.

We have used the Zemax optical design software to obtain the spot diagrams for our échelle spectrograph, using the input parameters very close to the parameters of commercially available optical elements.

The parameters used in the optical design are listed in Table 1. The results are shown in Figure 3, which contains the spot diagrams for five representative orders:

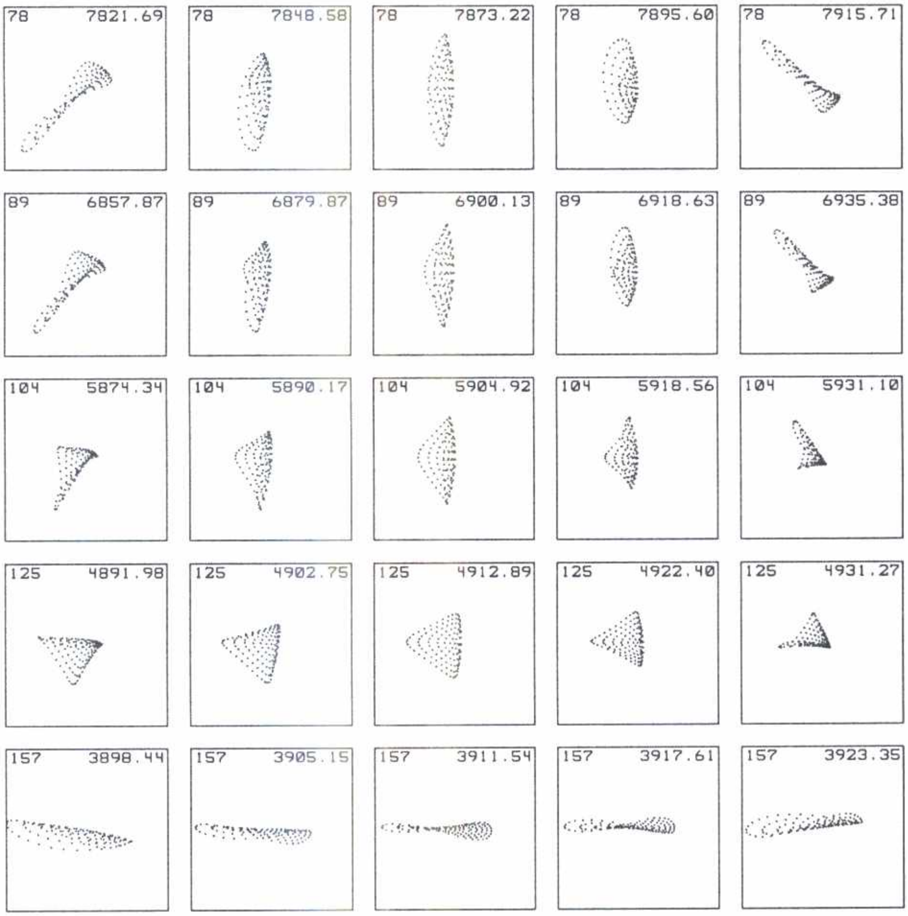

Figure 3: MILES spot diagrams.

78, 89, 104, 125 and 157, as indicated in the upper-left corner of each diagram, and for five different wavelengths (indicated in the upper-right corner, in Angstroms). The total spectral range is between about 390 nm and 790 nm. Each box represents 2×2 pixels (30 μm squared). A quick analysis of the spot diagrams shows that for each examined spectral order and wavelength the light rays at the camera focal plane stay mainly within one pixel. Therefore, the proposed optical design does not decrease the spectral resolution of the spectrograph.

From Table 1, the expected combined cost of the spectrograph's elements is 285 kEU. The total cost, including the spectrograph elements, transport, insurance, salaries of optical and mechanical engineers etc. is evaluated to about 550 kEU.

7. CONCLUSION

A high resolution spectrograph (MILES) for the Milanković telescope is described. A

Table 1: Parameters of optical elements.

Element	**Properties**	**Commercial price (kEU)**
Optical fibre	Core diameter: 50 μm Length: $\sim$ 20 m	5
Collimators	Parabolic mirrors (2 pieces) Diameter: 30 cm Focal length: 120 cm	5
Echelle grating	Grating Surface: ruled Groove Frequency: 31.6 per mm Blaze Angle: 76° ($\tan\theta_B = 4$) Groove Length: 100 mm Ruled Width: 400 mm	60
Cross disperser	Two identical prisms Dimensions: 140×140 mm Apex angle: 40°	25
Camera	Diameter: 140 mm Focal length: 640 mm	10
CCD	Pixel size: 15 μm Chip dimensions: 4096×4096 pixels	160
Optical table	Thickness: 30 cm Width: 120 cm Length: 240 cm	10
Other optical and mechanical elements		10

white-pupil design is proposed, as it gives a relatively small pupil on the entrance to the cross-disperser and camera, resulting in a significant cost saving and complexity reduction.

When compared to other commercially available spectrographs of a similar design and comparable performance, the estimated price of the MILES spectrograph is by over 50% lower. This is a significant factor that needs to be taken into account when the instrument is acquired.

ACKNOWLEDGEMENTS. This research is part of the projects No. 176021 "Visible and invisible matter in nearby galaxies: theory and observations" and No. 176004 "Stellar Physics" supported by the Ministry of Education, Science and Technological Development of the Republic of Serbia.

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Publ. Astron. Obs. Belgrade No. 92 (2013), 47 - 52 *Contributed paper*

FOLLOW-UP LUCKY IMAGING OBSERVATIONS OF *KEPLER* TARGETS

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Abstract. The image scale of *Kepler* space telescope is $>4''$/pixel, thus point sources are highly undersampled. Follow-ups with lucky imaging is therefore an essential observation for the proper interpretation of *Kepler* light curves, especially when there is a suspect for blending. Here I scketch how unobscured telescopes perform for this task.

1. INTRODUCTION

The concept of how lucky imaging can lead to photometry of objects that otherwise blend together. Using cameras with negligible read-out noise and applying exposure times of 1-15 msec, one will be able to identify the sky conditions when instantaneous Point Spread Function (PSF) is a singlet which is at most slightly blurred. This is usualy done with observing the Strehl-ratio in each individual images, and combining only the best few-percentile of all observations – when the atmosphere was locally very smooth with very little influence on imaging.

We succesfully tested an Andor IXon 888 EMCCD camera for this task (see e.g. Szabo et al. 2010), which is practically photon-limited fast imaging system, able to run in photon counting mode. This is thank to the EM-pre-amplification before read-out, thus setting very high pre-amplification gains (in the order of 100 to even 1000), the read-out noise is highly outscored by photon noise, thus the system will be practically free from read-out noise.

Attached to the 1-meter RCC telescope of Konkoly Observatory, this camera is able to go to as faint as 10 magnitude limit with exposure times of 1–15 msec. Involving only the best 1-2% of all images in synthesis, we can get close to the quality of the image with the given instrument, but lacking speckle patterns and blurring of the atmosphere.

2. THE PROBLEM OF UNDERSAMPLING

There are 42 CCDs of 2200×1024 pixels size in *Kepler* camera head, leading to $M \approx 9.4 \times 10^7$ pixels. Following to the well-known "birthday paradox" of statistics, one can estimate the probability of having at least one blend if N stars are imaged, in linear approximation we have[1]

$$P(blend \mid M, N) \approx 1 - e^{\frac{-M^2}{2N}}. \qquad (1)$$

The surprising result is that if there were (only) 12,950 stars in the 94 Mpixel *Kepler* field, there would be 50% probability to have two stars blending in the same pixel. But instead of 12,950 stars, there are three orders of magnitude more, ≈13 million objects in the Kepler Input Catalog (KIC), leading to the conclusion that practically all stars in the *Kepler* field are blended.

This blending can be partially resolved relatively easily, because the pixel size of *Kepler* images, $> 4''$, is well above the resolution power of Earth-based instruments. Thus the strategy is to get as good resolution as possible and map at least the "microfield" around the most interesting KIC-objects. With this tool, one will be able to decide on

- The source of the interesting light variation;
- The light contamination from "not interesting" stars;
- The correction to this light contamination;
- And on the unbiased color indices of the surveyed object.

3. INSTRUMENTATION

Currently we could test the technique on telescopes designed for long exposures. Because seeing is very rarely below $1''$ from any site in Hungary, and these telescopes were designed for seeing-limited observations, these instruments have nonradial PSF distortions in the order of 0.6–$0.8''$.[2] Therefore, there are two ways for lucky imaging:

- image synthesys (or image reconstruction – "deconvolution" for extended objects), when the observed image is reconstructed as a set of point sources convolved with the known PSF, the unknowns are usually the astrometry and photometry; or
- constructing diffraction-limited optics with large Strehl ratio.

For the first possibility we performed detailed analyses in the case of the hierarchical triplet HD 181068 (i.e. Trinity; Derekas et al. 2011), and KOI-13, to identify securely the planet host in an Aitken's double star Szabó et al. 2011). We also give an imagery in Fig. 1 of present paper.

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[1] see `http://mathworld.wolfram.com/BirthdayProblem.html` for detailed derivation. Also here you can find a formula to estimate the probability function of having k-fold blends if you have N stars in M pixels.

[2] Which is natural. Building a telescope optics for seeing limited observations with much better PSF than your best seeing would evidently be a waste of money.

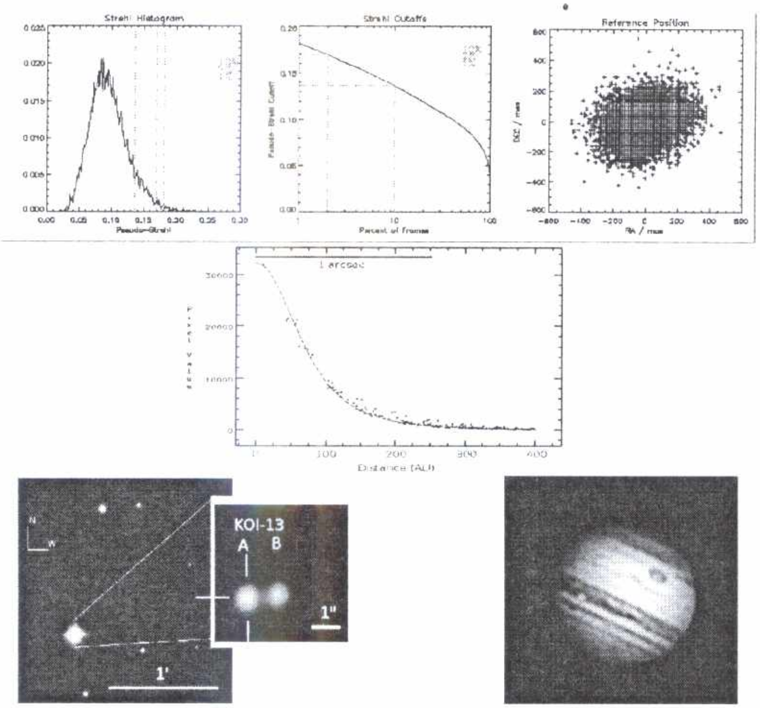

Figure 1: Upper panels: Density (left) and cumulative (middel) distribution of Strehl ratio in case of HD 181068. Top right: the standard deviation of astrometry is ≈100 mas in both coordinates for each individual images with large Strehl ratio. Middle: The environment of HD 181068 with lucky imaging shows no additional companions (Derekas et al. 2011). Bottom left: Wide-field and lucky image of the field with KOI-13. The size of the inset is exactly 1 *Kepler*-pixel. Bottom right: Jupiter with lucky imaging with the 1-meter RCC telescope (no additional image reconstruction has been applied).

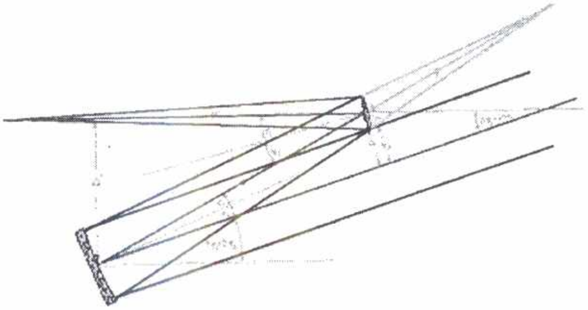

Figure 2: The scetch of the prototype Kutter telescope after Kutter's original book (1953). The primary mirror was an f/14.7 concave sphere with 110 mm diameter, the secondary was a convex sphere at 965 mm distance. The coma astigmatism was 2μm without an additional coma corrector.

Here I rather wish to concentrate on a possible new instrument designed for diffraction limited lucky imaging. Beside the accuracy of optical elements, the optical configuration is also extremely important. RCC or Cassegrain telescopes are quite suboptimal due to the large central obscuring by the secondary mirror. This results in a considerable light loss, and more importantly, dramatical decrease of the Strehl ratio. Centrally covered optics, id est, have slightly narrower disk but also highly amplified diffraction rings, and the contrast of this optical system is rather low. This results in much noise in image reconstruction steps. E.g. Gemini telescopes have a Strehl ratio of 30–55% in K-band even with active optics.[3] The RCC telescope at the Piszkéstető station of Konkoly observatory has a Strehl ratio around 25% at tranquil seeing conditions (Fig. 1).

Unobscured optics offer highly larger Strehl-ratio, because the central part of the aperture – which is the most important part to get contrast – can also collect light with full capacity. Tilted mirror telescopes such as Kutter and Yolo systems, can perform a Strehl ratio above 90% if the mirrors have accurate surface and positioning. This is close to the Strehl-performance of lens telescopes at ≈ 94–96%. The central peak provided by an obscured telescope contains as many photons if it has 1.7–2 times the diameter than a reference unobscured telescope. In other words, *if your telescope in unobscured, you can double the diameter in mind for lucky imaging performance.*

4. CONCLUSION

My suggestion is therefore designing and building a 0.6–0.8 meter unobscured telescope with very slightly oversampled imaging (e.g. diffraction limited FWHM≈3 pixels), dedicated for lucky imaging and fast photometry on the lucky basis. This instrument will be as fast as a ≈1.2-meter obscured telescope in lucky imaging performance, will provide a diffraction-limited resolution of 0.2″, and under favourable seeing conditions, the diffraction limited resolution can be approximated in practice, too. This telescope will be, on the other hand, lightweight and small enough for a relatively easy installation, and remote controll will be possible with simple technical support.

Turning to the *Kepler* field, the performance of this instrument will be similar to what a 30 Gpixel kamera head would provide in *Kepler* space telescope. This telescope will even not completely solve the blending problem in the *Kepler* field, but for one single blend with 50% probability there will be a need for 200,000 stars (15 times more than for *Kepler* space telescope), deepening the limit of unblended stars by 2 magnitudes; and offering a secure resolution in >99% of *Kepler* bands.

ACKNOWLEDGEMENTS. This project has been supported by by the János Bolyai Research Scholarship of the Hungarian Academy of Sciences, the Hungarian OTKA Grants K76816, K83790, K104607, MB08C 81013, a “Lendület-2009 Young Researchers” Program of the Hungarian Academy of Sciences. dI am grateful to the LOC, SOC and all contributors to the memorable BELISSIMA Conference in Beograd.

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[3] `http://www.noao.edu/meetings/ao-aas/talks/Christou_Gemini_AO_AAS.pdf`

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Publ. Astron. Obs. Belgrade No. 92 (2013), 53 - 54 *Invited lecture*

NEW MODES OF OBSERVATION AT THE 2-M TELESCOPE OF ROZHEN OBSERVATORY: PARAMETERS OF THE INSTRUMENTS AND FIRST RESULTS

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Abstract. Rozhen is the National astronomical observatory in Bulgaria. The main observing facility in the observatory is the 2-meter telescope. It was commissioned 30 years ago and over the years it was continuously developed and upgraded with new instruments. In this presentation I will report on the developments made in the last several years. With a new camera, used in the red channel of the focal reducer, the FOV is increased to 16 arcmin. A new slit unit, for the low-resolution spectroscopy mode with the focal reducer, allows fast positioning of the objects on the slit and their monitoring during exposures. After changes in the configuration of Wollaston prism and grism, now it is possible to perform spectropolarimetric observations with low spectral resolution. The introduction of a new set of Sloan filters extends the field of possible photometric tasks. The work on the fiber-fed bench-mounted echelle spectrograph is going on with expected start of operation by the mid of 2013.

Presentation link: `http://belissima.aob.rs/Conf2012/Bonev_2012.pdf`

Publl. Astron. Obs. Belgrade No. 92 (2013), 55 - 56 *Invited lecture*

ASTEROID PROPERTIES FROM PHOTOMETRIC OBSERVATIONS: CONSTRAINING NON-GRAVITATIONAL PROCESSES IN ASTEROIDS

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Abstract. From October 2012 we run our NEOSource project on the Danish 1.54-m telescope on La Silla. The primary aim of the project is to study non-gravitational processes in asteroids near the Earth and in their source regions in the main asteroidal belt. In my talk, I will give a brief overview of our current knowledge of the asteroidal non- gravitational processes and how we study them with photometric observations. I will talk especially about binary and paired asteroids that appear to be formed by rotational fission, about detecting the Yarkovsky-O'Keefe-Radzievskii-Paddack (YORP) and BYORP (binary YORP) effects of anisotropic thermal emission from asteroids that change their spins and satellite orbits, and about non-principal axis rotators (the so called "tumblers") among the smallest, super-critically rotating asteroids with sizes $<$ 100 meters.

Presentation link: `http://belissima.aob.rs/Conf2012/Pravec_2012.ppt`

Publ. Astron. Obs. Belgrade No. 92 (2013), 57 - 62 *Contributed paper*

ECLIPSING BINARIES - PRECISE CLOCKS TO DISCOVER EXOPLANETS

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Abstract. Observational campaign Dwarf aimed at detection of circumbinary extrasolar planets using the timing of the minima of low-mass eclipsing binaries is presented. The observations are collected within an extensive network of $\sim$ 20 to 200 cm telescopes. The starting sample of the objects to be monitored contains (i) low-mass eclipsing binaries with M and K components, (ii) short-period binaries with a sdB or sdO component, and (iii) post-common-envelope systems containing a WD, which enable us to determine minima with high precision. Because the light-time effect amplitude caused by additional component to an eclipsing binary increases with its the orbital period, the timescale of the project is at least 5-10 years.

1. INTRODUCTION

Observing campaign Dwarf focuses at detection and characterization of extrasolar planets orbiting eclipsing binary stars (see the white paper of Pribulla et al., 2012). The only similar campaign, is the Polish project SOLARIS monitoring the Southern sky (Konacki et al. 2011). The presented project is a collaboration of more than 30 observatories including several well-equipped amateur astronomers.

The eclipses act as an accurate clock for detecting other objects revolving around the inner binary. The observations enable us to determine their orbital parameters from the *observed* $-$ *calculated* residuals of minima times. The timing technique proved to be the most fruitful in detecting circumbinary planets. The exoplanet encyclopedia[1] lists (as of February 22, 2012) 12 planetary systems (15 planets/4 multiple planet systems) detected by timing.

In the past decade, the eclipse timing has been used to infer the existence of multiple low-mass planetary objects to a couple of binaries. A two-planet system orbiting HW Vir (sdB+M dwarf binary) was found by Lee et al. (2009). Recently, circumbinary planets were announced around a couple of post-common-envelope systems: two planets around NN Ser (Beuermann et al. 2010), two giant planets orbiting UZ For (Potter et al. 2011), a single planet around DP Leo (Qian et al. 2010), HU Aqr (Qian et al. 2011; Gozdziewski et al. 2012), and RR Cae (Qian et al. 2012).

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[1] `http://www.exoplanet.eu/catalog.php`

Because the timing technique is sensitive to extrasolar planets on long-period orbits, the archival data play an important role. The major problem when using published timings is the inhomogeneity of the data mostly caused by different approaches to determine the minima. The original light curves (LCs) are usually hard to come by. The situation is exacerbated by many mistakes such as heliocentric correction missing, time shifted by one hour or typos. The minima uncertainties are often not available or underestimated.

2. TARGET SELECTION

Chances to discover a circumbinary substellar body depend primarily on three factors: (i) the precision and number of the minima which can be achieved; (ii) the semi-amplitude of the LITE caused by the body; (iii) the intrinsic variability of the binary causing noise in minima timings. The suitability of an object can be defined as the peak-to-peak amplitude of LITE caused by such a body, ΔT, divided by the theoretical precision of a single minimum timing, Δt. For systems with a triangular shape of the minima (i.e., binaries with partial eclipses and non-degenerate components) we have (see Sybilski et al., 2010; Pribulla et al., 2012):

$$\Delta t = \frac{D\sigma}{2d\sqrt{N}}, \tag{1}$$

where d is the depth and D the duration of the minimum, σ is the uncertainty of a single observational point, and N the number of observational points during the eclipse. It is clear, that the most precise are deep and narrow minima of bright objects. The sampling frequency and precision of observations primarily depend on the diameter of the telescope used and the brightness of the object. Assuming zero read-out times, it can be shown that (Pribulla et al., 2012):

$$\Delta t = \frac{1}{\sqrt{\tau F_\lambda}} 10^{0.2(m_\lambda + X\kappa_\lambda)} \frac{\sqrt{D}}{\sqrt{\pi} A d}. \tag{2}$$

where $\tau \in (0,1)$ is the throughput of the observing system, F_λ is number of photons from a $m_\lambda = 0$ star per square meter and per second outside Earth atmosphere recorded through the filter used, X is airmass, κ_λ is the extinction coefficient, and A is the aperture or the diameter of the telescope. Because of several other sources of the noise (scintillation, read-out, sky background...) and non-negligible read-out times the minima uncertainties as estimated by the above relation should be regarded as the theoretical limits. The estimates, nevertheless, immediately show the suitability of the selected targets for the present project.

It can easily be shown, that the full amplitude (Max - Min or peak-to-peak) of the expected LITE changes caused by another body orbiting a binary on the edge-on ($i \sim 90°$) circular orbit ($e \sim 0$) is:

$$\Delta T \approx \frac{2M_3 G^{1/3}}{c} \left[\frac{P_3}{2\pi(M_1 + M_2)}\right]^{2/3}, \tag{3}$$

where M_1, M_2, M_3 are the masses of the components, G is gravitational constant, c is speed of light, and P_3 is orbital period of the third (substellar) component.

It is clear, that the most advantageous are low-mass eclipsing binaries orbited by massive sub-stellar companions on long-period orbits. The advantage of low-mass binaries is, on the other hand, offset by their surface activity causing noise and spurious periodicities in the timing data. Dark photospheric spots seen in the majority of the late-type systems cause LC asymmetries (O'Connell effect) and out-of-eclipse photometric wave(s). A spot seen by the observer close to or during the minimum of light shifts it from the spectroscopic conjunction. The maximum time shift caused by a single starspot can be estimated as follows (see Pribulla et al., 2012):

$$|\Delta t| = \frac{\pi}{4}\frac{A_{OCE}D^2}{dP}, \tag{4}$$

where A_{OCE} is peak-to-peak amplitude of the out-of-eclipse photometric wave, D is the duration of minimum, P is the orbital period, and d is the depth of eclipse. Pulsations of the sdB components are of much less concern (Kilkenny, 2011).

To get the highest possible accuracy and precision of the eclipse timings necessary to detect exoplanets, we selected low-mass eclipsing systems with sharp and deep minima. The following three groups of objects were included: (i) systems with K or/and M dwarf components, (ii) systems with a hot subdwarf (sdB or sdO) and a K or M dwarf component, (iii) post-common-envelope systems with a white dwarf (WD) component. Only detached binaries are considered. Because all observatories participating in the campaign are north of the 30th parallel, we excluded objects having DEC $< -10°$. To collect as many minima as possible, and to fully cover a minimum in one night from mid-latitudes we excluded objects with orbital periods longer than 10 days. The brightness range of our preliminary sample is $R =$ 10-17 mag, which fits the possibilities of small telescopes with apertures of 20 to 200 cm equipped with a low-end CCD camera and at least the VRI filter set. The preliminary target list (Pribulla et al., 2012) is frequently being updated (see `http://www.ta3.sk/~pribulla/Dwarfs/`).

3. DATA REDUCTION AND ANALYSIS

The reduction of the CCD frames will be done using the standard approach. In the first step, the master dark and master flat-field frames will be produced for all exposure times, filters and CCD temperatures. To reduce effects of scattered light usually seen in sky flatfields the master flat fields will be box-car average divided to remove low-frequency variations while pixel-to-pixel sensitivity differences will be preserved. In the next step, the raw CCD frames will be dark and flatfield corrected. Then the WCS system will be determined using the GSC 2.3.3 online catalogue for reference[2]. Finally, aperture photometry of the target and suitable (stable) comparison star will be performed. The numerical aperture giving the smallest noise will be selected.

To secure uniform time basis for all observations, the data from individual observatories will be collected in geocentric JD based on UTC. The time will then be transformed to Barycentric Julian Date in Barycentric Dynamical Time (BJD-TDB). During the campaign we will attempt to quantify the shutter-delay effect which depends on the camera type and systematically shifts the observed timings.

The minima timings will be determined with a method similar to cross-corellation technique used to determine precise radial velocities. For each eclipsing binary (EB),

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[2] `http://gsss.stsci.edu/webservices/GSC2/GSC2WebForm.aspx`

the fitting templates will be prepared to obtain the instant of conjunction (minimum) for any sufficiently long photometric sequence. In such a way, we will use not only the minima but also other LC segments where the brightness sufficiently changes. Due to the differences in filter transparencies and wavelength response of detectors, we will form a template LC for each filter separately. To obtain good fits of the template $T(x)$ to the observed LCs (and accurate timings), we constructed the following fitting function (see Pribulla et al. 2008):

$$F(x) = A + Bx + CT(x - D), \tag{5}$$

which would allow for shifting, scaling and 'slanting' of the template LC. Fixing of the parameters will be judged according to the appearance of individual LCs, e.g. in the case that only one branch was observed the vertical shift (A) would be fixed to zero. The minima uncertainties will be checked by a Monte Carlo simulation approach. To preserve the original shape and scatter of the data, the fitting function $F(x)$ in the instants of real observations will be replicated adding the Gaussian-distributed random noise. The standard deviation of the added noise will correspond to the standard deviation of the original data with respect to the original fit. Preliminary tests show that about 2000 replications of the LC are sufficient to arrive at the errors.

If an unseen third component revolves an EB, the residuals with respect to a linear (or quadratic) ephemeris will show a wavelike behavior in the (O-C) diagram because of the LITE. The observed times of minima then follow the relation below (see Irwin, 1959):

$$\begin{aligned} Min\ I = JD_0 + P \times E + Q \times E^2 + \\ + \frac{a_{12} \sin\ i}{c} \left[\frac{1 - e^2}{1 + e \cos\ \nu} \sin(\nu + \omega) + e \sin\ \omega \right], \end{aligned} \tag{6}$$

where a_{12} sin i is the projected semi-major axis (inclination cannot be derived from the LITE alone), e is the eccentricity, ω is the longitude of the periastron, ν is the true anomaly of the EB orbit around the common center of the mass of the whole system. $JD_0 + P \times E + Q \times E^2$ is the quadratic ephemeris of the minima of the EB and c is the velocity of light. To obtain the optimal fit and corresponding elements (JD_0, P, Q, $a \sin i$, e, ω, and also the epoch of periastron passage, T_0, and the period of the orbit of the three-body system, P_3) of the LITE orbit including errors, we use the differential corrections method (see Irwin 1959). Knowing the semi-amplitude of LITE, A, period of third-body orbit, P_3 and the total mass of the binary, $M_1 + M_2$, and assuming that $M_3 \ll M_1 + M_2$, we can determine the mass of the third component:

$$M_3^3 \sin^3 i \approx \frac{4\pi^2 (M_1 + M_2)^2}{G P_3^2} A^3 c^3 \tag{7}$$

where i is the inclination of the orbital plane, and G is the gravitational constant.

The analysis of the selected EBs timings will be performed in the following three steps: (i) period search in the (O-C) residuals with respect to a linear or quadratic ephemeris, (ii) fitting LITE orbits to most promising orbital periods, (iii) excluding possible spurious detections caused by, e.g. the Applegate's (1992) mechanism. Except CM Dra, which shows small orbital eccentricity, both types of minima can be simultaneously analyzed. A major problem in the timing analysis is matching our uncertainties with those listed for the published timings.

4. OBSERVING NETWORK AND STRATEGY

The targets (see Table 1 of Pribulla et al., 2012, for the preliminary list) will be observed at several observatories using 20-120 cm telescopes equipped mostly with low-end CCD cameras. In addition to the original list of observatories (Table 2 of Pribulla et al., 2012), a couple of well-equipped amateur astronomors decided to join. The role of smaller telescopes is mainly to characterize newly-detected eclipsing binaries, e.g. within NSVS or HAT networks. The first observations show that the true type of variability, the ephemeris or amplitude of the object are often different from those given in the original catalogue. The larger telescopes will concentrate on faint and short-period objects, mainly post-common-envelope binaries. The 2m telescope at the Rozhen observatory in Bulgaria will obtain medium-resolution spectroscopy of objects without any spectroscopy to infer the nature and spectral type of the components and to exclude systems with stellar third or multiple components.

To get the best S/N (and the highest precision of the timings) it is advisable to use the R or I filters for M or K EBs (see Section 2), and the V filter (or B in the case of back-illuminated CCDs) for the systems with sdB or WD components, where the eclipse depth quickly increases to the shorter wavelength range. Several faint or short-period objects will be observed without filter to provide more light. Using two or more filters would decrease the cadency of the photometry and decrease the duty cycle because of filter change overheads. For short-period systems it is advisable to cover both minima shoulders to see the LC asymmetry caused by the photospheric spots.

In addition to the observations focused on the exact timing, we will perform (much less extensive) multi-color $UBVRI$ photometry of the same fields to find the best comparison stars (to minimize the second-order extinction effects). The observations will also be focused to check possible out-of-eclipse and color brightness variations which would indicate the mechanism causing cyclic variations of the orbital period proposed by Applegate (1992).

Systematic CCD observations of the targets started at the Stará Lesná Observatory in February 2012. The precision of the data is good but still hardly approaching the theoretical limits discussed in Section 2. The best error estimates of 4 primary minima determined from the preliminary reduction (differential photometry with respect to one comparison) of the CCD photometry of NY Vir (March 16, 24, and 26, 2012) range between 1.7 and 3.5 seconds while the theoretically estimated limit is 0.6 seconds. This results from the red noise in the data (no autoguider available), possible variability of the comparison star (GSC 4966-00559), and read-out overheads.

5. CONCLUSION

The presented project is aimed at the detection of circumbinary extrasolar planets and brown dwarfs using minima timing variability of carefully selected EBs. Unlike more widespread techniques (RV or transit searches) to detect extrasolar planets, the minima timing does not require high-end and costly astronomical instrumentation.

Precise photometric observations of the brightest targets of our sample can be performed by well-equipped amateur astronomers. The chances to detect circumbinary bodies does not depend only on the precision of the individual timings but also on the number of participating institutions and devoted amateurs and number of targets monitored.

The theoretical estimates show that the timing technique enables to detect circumbinary planets down to Jupiter mass orbiting on a few-years orbits. The merit of an EB strongly depends on its brightness, depth, and width of the minima, less on the mass of the underlying eclipsing binary.

The observations within the project promise additional useful science such as: (i) the study of spot cycles in the RS CVn-like late-type binaries, detection of flares (see Pribulla et al., 2001), (ii) a more accurate characterization of recently-discovered detached eclipsing binaries, (iii) detection of new low-mass EBs which is crucial to better define the empirical lower main sequence, (iv) determination of absolute parameters of the components (in the case that spectroscopic orbits are available), (v) detection of EBs with pulsating component(s), (vi) detection and characterization of multiple systems with two systems of eclipses, (vii) detection of new variable stars in the CCD fields covered, (viii) photometric detection of transits of substellar components across the disks of the components of the eclipsing pair.

The LITE can always be regarded *only* as a very good indication of a substellar body in the system. In nearby systems with a sufficiently close visual companion (e.g., CU Cnc, GK Boo) the LITE on a long-period orbit could be possibly checked using the differential astrometry of the visual pair.

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SURVEYS WITH INNOVATIVE ONE-METER TELESCOPES: ASTEROIDS, DEBRIS,...

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Abstract. Telescopes of the 1 m class with innovative optical systems can be compliant with the requirements of very advanced surveys for fast moving objects, including Near Earth Objects (NEO) and Space Debris (SD). To guarantee discovery of NEO impactors in time for mitigation the requirements include an extremely wide field of view, with small pixel size, and fill factor close to 1. For discovery of SD, to protect space assets from catastrophic fragmentation, also very fast readout and angular motion are required. We will present a new telescope design with 45 square degrees field of view, the software and algorithms allowing to detect the trails and to compute the orbits for fast moving objects. Innovative software and hardware are the elements of a survey system capable of extraordinary performances and with many other possible applications.

Presentation link: `http://belissima.aob.rs/Conf2012/Milani_2012.pdf`

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EXOPLANET SEARCHES WITH GRAVITATIONAL MICROLENSING

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Abstract. There are different methods for finding exoplanets such as radial spectral shifts, astrometrical measurements, transits, timing etc. Gravitational microlensing (including pixel-lensing) is among the most promising techniques with the potentiality of detecting Earth-like planets at distances about a few astronomical units from their host star. We emphasize the importance of polarization measurements which can help to resolve degeneracies in theoretical models. In particular, the polarization angle could give additional information about the relative position of the lens with respect to the source.

1. INTRODUCTION

Already before the discovery of exoplanets Mao & Paczynski (1991) showed how efficient is gravitational microlensing as a tool to search for extrasolar planets, including the low mass ones, even at relatively large distances from their host stars. Later on, observations and simulations gave the opportunity to confirm the robustness of Mao & Paczynski (1991) conclusions. Exoplanets near the snow line may be also detected

Table 1: Exoplanets discovered with microlensing.

Star Mass ($M_\odot$)	Planet Mass	Star–planet Separation (AU)
$0.63^{+0.07}_{-0.09}$	$830^{+250}_{-190}M_\oplus$	$4.3^{+2.5}_{-0.8}$
0.46 ± 0.04	$(1100 \pm 100)M_\oplus$	(4.4 ± 1.8)
$0.22^{+0.21}_{-0.11}$	$5.5^{+5.5}_{-2.7}M_\oplus$	$2.6^{+1.5}_{-0.6}$
$0.49^{+0.14}_{-0.18}$	$13^{+4.0}_{-5.0}M_\oplus$	$3.2^{+1.5}_{-1.0}$
0.50 ± 0.04	$(226 \pm 25)M_\oplus$	(2.3 ± 0.2)
0.50 ± 0.04	$(86 \pm 10)M_\oplus$	(4.6 ± 0.5)
$0.64^{+0.21}_{-0.26}$	$20^{+7}_{-8}M_\oplus$	$3.3^{+1.4}_{-0.8}$
$0.084^{+0.015}_{-0.012}$	$3.2^{+5.2}_{-1.8}M_\oplus$	$0.66^{+0.19}_{-0.14}$
$0.30^{+0.19}_{-0.12}$	$260.54^{+165.22}_{-104.85}M_\oplus$	$0.72^{+0.38}_{-0.16}/6.5^{+3.2}_{-1.2}$
0.67 ± 0.14	$28^{+58}_{-23}M_\oplus$	$1.4^{+0.7}_{-0.3}$
$0.38^{+0.34}_{-0.18}$	$50^{+44}_{-24}M_\oplus$	$2.4^{+1.2}_{-0.6}$
$0.19^{+0.30}_{-0.12}$	$2.6^{+4.2}_{-1.6}M_J$	$1.8^{+0.9}_{-0.7}$
0.56 ± 0.09	$10.4 \pm 1.7M_\oplus$	$3.2^{+1.9}_{-0.5}$
$0.44^{+0.27}_{-0.17}$	$2.4^{+1.2}_{-0.6}M_J$	$1.0 \pm 0.1/3.5 \pm 0.5$
$0.67^{+0.33}_{-0.13}$	$1.5^{+0.8}_{-0.3}M_J$	2^{+3}_{-1}
$0.75^{+0.33}_{-0.41}$	$3.7 \pm 2.1M_J$	$8.3^{+4.5}_{-2.7}$
0.26 ± 0.11	$0.53 \pm 0.21M_J$	$2.72 \pm 0.75/1.50 \pm 0.50$

with this technique as it was shown, for instance, in Fig. 8 in Mao (2012). Moreover, in contrast with conventional methods, such as transits and Doppler shift measurements, gravitational microlensing gives a chance to find exoplanets not only in the Milky Way (Beaulieu et al. 2006, Dominik 2010, Wright & Gaudi 2012, Gaudi 2012, Mao 2012), but also in nearby galaxies, such as the Andromeda galaxy (Ingrosso et al. 2009, 2011), so pixel-lensing towards M31 provides an efficient tool to search for exoplanets and indeed an exoplanet might have been already discovered in the PA-N2-99 event (An et al. 2004, Ingrosso et al. 2009). Since source stars for pixel-lensing towards M31 are basically red giants (and therefore, their typical diameters are comparable to Einstein diameters and the caustic sizes) one has to take into account the source finiteness effect (Pejcha & Heyrovský, 2009). In the case of relatively small size sources, the probability to have features due to binary lens (or planet around star) in the light curves is also small since it is proportional to the caustic area. Giant star sources have large angular sizes and relatively higher probability to touch caustics (Ingrosso et al. 2009).

2. EXOPLANET SEARCHES WITH GRAVITATIONAL MICROLENSING

Since the existence of planets around lens stars leads to the violation of circular symmetry of lens system and, as a result, to the formation of fold and cusp type caustics (Schneider, Ehlers, Falco 1992, Zakharov 1995, Petters, Levine, Wambsganss, 2001), one can detect extra peaks in the microlensing light curve due to caustic crossing by the star source as a result of its proper motion.

A list of exoplanets detected with microlensing searches toward the Galactic bulge is given in Table 1 (see, Bennett et al. 2006; Bennett et al. 2008; Bennett 2008;

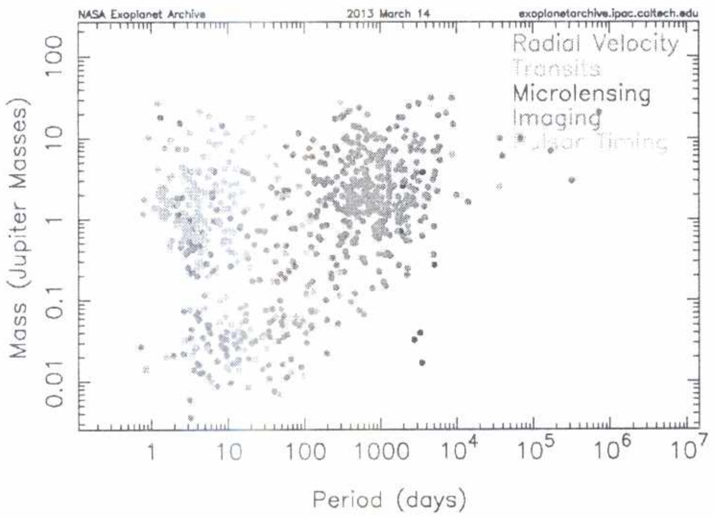

Figure 1: All exoplanets found with different techniques until March 14, 2013, see http://exoplanetarchive.ipac.caltech.edu/exoplanetplots/.

Dong et al. 2009; Mao 2012; Kains et al. 2013). For some planetary systems two probable regions for the planet-to-star distance are given due to the planet and star-lens parameter degeneracy (Dominik 1999; Bennett 2009), see rows 9, 14, 17 in Table 1. Reports about these discoveries were published by Bond et al. (2004); Udalski et al. (2005); Beaulieu et al. (2006); Gould et al. (2006); Gaudi et al. (2008); Bennett et al. (2008); Dong et al. (2009a,b); Janczak et al. (2010); Miyake et al. (2011); Batista et al. (2011); Muraki et al. (2011); Yee et al. (2012); Bachelet et al. (2012); Bennett et al. (2012). It is remarkable that the first exoplanet has been discovered by the MOA-I collaboration with only a 0.6 m telescope (Bond et al. 2004; Bennett 2009). This microlensing event was also detected by the OGLE collaboration, but the MOA observations with a larger field of view CCD, made about 5 exposures per night for each of their fields. This was an important advantage and shows that even observations with modest facilities (around 1 meter telescope size and even smaller) can give a crucial contribution in such discoveries. Until now four super-Earth exoplanets (with masses about $10M_\oplus$) have been discovered by microlensing (see Table 1 and Fig. 1), showing that this technique is very efficient in detecting Earth mass exoplanets at a few AU from their host stars, since a significant fraction of all exoplanets discovered with different techniques and located in the region near the so-called snow line (or the habitable zone) found with gravitational microlensing. Some of these exoplanets are among the lighest exoplanets see lines 3 and 8 in Table 1. For comparison, Doppler shift measurements help to detect an Earth-mass planet orbiting our neighbor star a Centauri B. The planet has an orbital period of 3.236 days and is about 0.04 AU from the star (Dumusque et al. 2012). Recently, a sub-Mercury size exoplanet Kepler-37b has been discovered with a transit technique (Barclay et al., 2013). It means that the existence of cool rocky planets is a common phenomenon in the Universe (Beaulieu et al. 2006; Dominik 2006; Dominik, Horne, Bode, 2006). Moreover, recently, Cassan et al. (2006) claimed that around 17% of stars host Jupiter-mass planets ($0.3 - 10\ MJ$), cool Neptunes ($10 - 30 M_\oplus$) and super-Earths ($10 - 30 M_\oplus$) have relative abundances per star in the Milky Way such as 52% and 62%, respectively. Analysis of Kepler space telescope data also shows that a significant fraction of all stars has to have exoplanets (Fressin et al. 2013). Pixel-lensing towards M31 may provide an efficient tool to search for exoplanets in that galaxy (Chung et al. 2006; Kim et al. 2007; Ingrosso et al. 2009), and indeed an exoplanet might be already discovered in the PA-N2-99 event (Ingrosso et al. 2009). Since source stars for pixel-lensing towards M31 are basically red giants (and therefore, their typical diameters are comparable to Einstein diameters and the caustic sizes) one has to take into account the source finiteness effect, similarly to microlensing in quasars (Agol & Krolik 1999; Popović et al. 2006; Jovanović et al. 2008; Zakharov, 2009). As it is well known the amplifications for a finite source and for a point-like source are different because there is a gradient of amplification in respect of a source area. If the source size is rather small, the probability to produce features of binary lens (or planet around star) is proportional to the caustic area. However, giant stars have large angular sizes and relatively higher probability to touch planetary caustics (see Ingrosso et al. 2009, for more details).

3. POLARIZATION CURVES FOR MICROLENS SYSTEMS WITH EXOPLANETS

For extended sources, the importance of polarization measurements was pointed out by Bogdanov, Cherepashchuk & Sazhin (1996) for point-like lens and by Agol (1996) for binary lens (see also, Ignace, Bjorkman & Bryce (2006)). For point-like lens polarization could reach 0.1% while for binary lens it could reach a few percent since the magnification gradient is much greater near caustics. It has been shown that polarization measurements could resolve degeneracies in theoretical models of microlensing events (Agol, 1996). Calculations of polarization curves for microlensing events with features in the light curves induced by the presence of an exoplanet and observed towards the Galactic bulge have been done (Ingrosso et al., 2012). Here we emphasize that measurements of the polarization angle could give additional information about the gravitational microlensing model. For instance, for a point-like lens the direction for the maximal polarization (which is perpendicular to the line connecting star and lens) may allow to infer the direction of lens proper motion, thus allowing to eventually pinpoint the lens in following observations. Even in the case of binary lens, the orientation of polarization vector corresponds to the orientation of the fold caustic (or more correctly to the tangent vector to the fold caustic at the intersection point with the path of source), provided the source size is small enough.

In Fig. 2, the polarization curve and the polarization angle are shown for the OGLE-2005-BLG-169 event, where a binary system formed by a main sequence star with mass $M_\odot \sim 0.5\ M_\odot$ and a Neptune-like exoplanet with mass about 13 $M_\oplus$ is expected from the light curve analysis (Gould et al., 2006). The event parameters are $t_E = 42.27$ days, $u_0 = 1.24 \times 10^{-3}$, $b = 1.0198$, $q = 8.6 \times 10^{-5}$, $\alpha = 117.0$ deg, $\rho_* = 4.4 \times 10^{-4}$, where $t_E, u_0, b, q, \alpha, \rho_*$ are the Einstein time, the impact parameter, the projected distance of the exoplanet to the host star, the binary component mass ratio, the angle formed by the source trajectory and the separation vector between the lenses, and the source star size, respectively (all distances are given in R_E units).

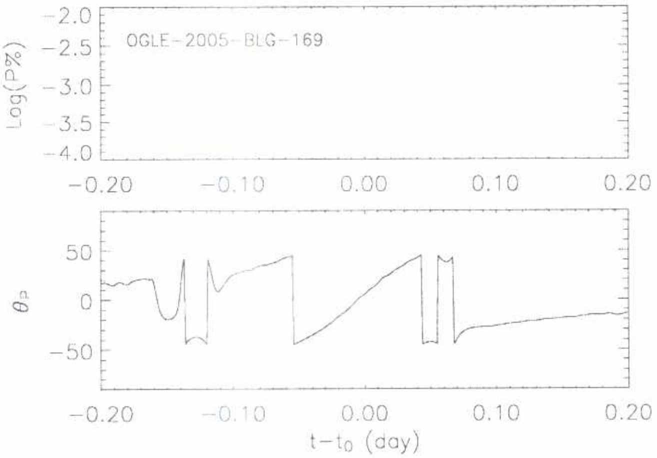

Figure 2: Polarization curve (top panel) and polarization angle (bottom panel) for the OGLE-2005-BLG-169 event.

The effect of the source transiting the caustic (see Gould et al. (2006) is clearly visible both in the polarization curve (see top panel in Fig. 2) and in the flip of the polarization angle (see bottom panel). We would like to stress that the high peak magnification ($A \simeq 800$) of the OGLE-2005-BLG-169 event leading to I-magnitude of the source about 13 mag at the maximum gives the opportunity to measure the polarization signal for such kind of events by using present available facilities. In this case, polarization measurements might give additional information about the caustic structure, thus potentially allowing to distinguish among different models of exoplanetary systems. Recently, Gould et al. (2012) found that a variable giant star source mimics exoplanetary signatures in the MOA-2010-BLG-523S event. In this respect, we emphasize that polarization measurements may be helpful in distinguishing exoplanetary features from other effects in the light curves.

4. CONCLUSIONS

Now there are campaigns of wide field observations by Optical Gravitational Lensing Experiment (OGLE) (Udalski, 2003) and Microlensing Observations in Astrophysics (MOA) (Bond et al., 2001) and follow-up observations MicroFUN[1] and PLANET[2]. It is important to note that small size (even less than one meter diameter) telescopes acting in follow-up campaigns contributed in discoveries of light Earth-like exoplanets and it is a nice illustration that a great science can be done with modest facilities. As it was shown by Ingrosso et al. (2012) polarization measurements are very perspective to remove uncertainties in exoplanet system determination and they give an extra proof for a conventional gravitational microlens model with suspected exoplanets.

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[1] http://www.astronomy.ohio-state.edu/ microfun/microfun.html.

[2] http://planet.iap.fr/.

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GAIA MISSION AND 1M-CLASS TELESCOPES

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Abstract. The GAIA mission and the importance of 1m-class telescopes are presented.

Presentation link: `http://belissima.aob.rs/Conf2012/Eyer_2012.pdf`

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Abstract. Accurate radial velocity observations of radially pulsating stars enable the determination of full set of physical parameters, such as the radius, temperature, luminosity, mass and evolutionary age. On the other hand, currently running transiting exoplanet search projects are delivering literally thousands of candidates in a desperate need for RV confirmation. Here we discuss how recent advances in optical spectroscopy have made it possible to measure Doppler velocities down to ±50 m/s with surprisingly small optical telescopes. Using the recently installed 0.5 m RC telescope of the ELTE Gothard Astrophysical Observatory and the 1m RC telescope of the Konkoly Observatory, we have collected extensive observations of pulsating stars as well as exoplanet host stars in the apparent brightness range of V=4 to V=12 magnitudes. We measure radial velocities with the cross-correlation technique and the achieved velocity precision ranges from 50 m/s to 500 m/s, depending on the brightness of the targets. Our results indicate that measuring sub-km/s radial velocities has become an affordable technique available to small national or university observatories, opening up a whole new avenue into the spectroscopic studies of moderately faint (V ∼ 10-12 mag) stars.

Presentation link: `http://belissima.aob.rs/Conf2012/Kiss_2012.pdf`

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FROM THE FIRST CCD MEASUREMENTS OF DOUBLE STARS AT VIDOJEVICA TOWARDS SPECKLEINTERFEROMETRY

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Abstract. A review of CCD measurements series for double and multiple stars performed to date at the Astronomical Station on Vidojevica with cameras Apogee Alta U42 and SBIG ST 10ME is presented. The quality of frames obtained with these cameras, as well as their limiting possibilities, is considered. A plan for furnishing the equipment for speckleinterferometry techniques and the expected improvement concerning the resolving of very close components of double stars are also presented.

1. INTRODUCTION

The first series of measurements of visual double stars at the recently opened Astronomical Station of Vidojevica (ASV) took place on June 18/19 2011 with CCD camera SBIG ST-10ME. A set of 15 double stars was the subject. The second and third series were realised on August 19/20 and October 20/21 2011, when CCD camera Apogee Alta U42 was used. In August frames of 20 double or multiple stars were obtained, in October 58 ones. During the fourth series of visual double stars, which took place in November 2011 (from 2 to 4), the SBIG ST-10ME camera was used again and frames of 114 double or multiple stars were obtained. The results of the first two series have been already reported (Stojanović at al. 2012), whereas the analysis of an interesting multiple star, which had resulted from observations done at ASV, was published in another paper (Cvetković et al. 2012b).

During 2012 two more observational series took place: fifth on April 22/23, when images of 16 double stars were obtained, sixth from June 21 to June 24, when images of 101 double or multiple stars were obtained. In both cases the Apogee Alta U42 camera was used.

In the beginning our aim was to find out how close double stars one can observe with this telescope and the cameras, i.e., to establish the minimum separation between the components still resolvable on the CCD frames. This depends on the apparent magnitudes of the pair components (m_A and m_B) and on the magnitude difference ($\Delta m = m_A - m_B$). Besides, there are other factors which affect the resolving of components: telescope resolving power, capabilities of cameras and seeing. Subsequently, our observing programme was aimed to include double or multiple stars not measured over the last ten years or generally with a small number of measurements.

Table 1: Some characteristics of the observing nights.

date	Temperature		Humidity		mean seeing
	beginning $[^\circ C]$	end $[^\circ C]$	beginning [%]	end [%]	[arcsec]
18/19 June 2011	18	8	81	85	1.4
19/20 August 2011	23	19	42	61	1.3
20/21 October 2011	10	8	59	85	2.3
2/3 November 2011	7	5	64	80	1.2
3/4 November 2011	7	2	69	71	1.1
4/5 November 2011	5	2	72	82	1.9
22/23 April 2012	9	6	78	84	2.4
21/22 June 2012	23	20	47	56	1.3
22/23 June 2012	22	16	76	82	1.9
23/24 June 2012	22	16	77	83	1.9
24/25 June 2012	20	16	69	80	1.6

For the CCD camera SBIG ST-10ME, the chip size is 1.485×1.026 cm. The chip dimensions are 2148×1472 pixels, the pixel size is 6.8×6.8 micrometers. The field of view is 8.51×5.88 arcminutes and the pixel size is 0.23 arcseconds. For the CCD camera Apogee Alta U42, the chip size is 2.76×2.76 cm. The chip dimensions are 2048×2048 pixels, the pixel size is 13.5×13.5 micrometers. The field of view is 15.81×15.81 arcminutes and the pixel size is 0.46 arcseconds. For each star pair five frames were obtained at the minimum.

The focal length of a telescope is an important parameter in determining the angular pixel size. This parameter is used for the purpose of determining the relative coordinates (angular separation ρ and positional angle θ) of double and multiple stars. At the ASV we have collected observations of these objects using two CCD cameras, Apogee Alta U42 and SBIG ST-10ME, attached to the 60 cm telescope. Its original focal length is 600 cm as given by the manufacturer. To determine the telescope focal length more accurately for both attached detectors, we used angular-separation measurements from CCD images taken at ASV. The obtained focal lengths are: $F_{42} = (5989 \pm 7)$ mm using the CCD camera Apogee Alta U42 attached to the telescope, and $F_{10} = (5972 \pm 4)$ mm with the CCD camera SBIG ST-10ME attached to the telescope (Cvetković et al. 2012a).

In Table 1 we present some characteristics of the observing nights: date of observation; the temperature and the humidity at the beginning and at the end of the observing night and the mean seeing for the corresponding night. Due to the seeing perturbed stellar image the FWHM mean value is determined and given in this table. As can be seen, the seeing varies rather strongly, to exceed $2''$ at high humidity.

2. REVIEW OF CCD OBSERVATIONS

The way of selection of double stars for which frames were taken at ASV enabled us to include both faint and bright pairs (different magnitudes) and also to have the magnitude differences of the pairs and the pair separations within sufficiently wide intervals. In our sample of 324 observed visual double or multiple stars the magnitudes of the primary m_A (the brighter component of a pair) cover an interval from 4.52 to 13.00, whereas those of the secondary m_B (fainter component) are within 4.58 to 13.90. The magnitude differences Δm are within 0.0 to 4.93. For about half of the pairs, 154, the magnitude difference is small, between 0 and 0.5. In Fig. 1 (left) the frequency of the pairs versus magnitude difference is presented. The separations, angular distances between the components, are within $1''\!.63$ to $20''\!.0$. But there were multiples with wide pairs (separations larger than $20''$) and we measured them too. The frequency of the pairs versus separation is presented in Fig. 1 (right). For 50 pairs the separation exceeds $10''$, in the case of the remaining ones the separation interval lies between $1''\!.63$ and $10''\!.0$.) In the case of double stars with low separations (less than $2''\!.5$) we selected those with sufficiently small magnitude differences ($\Delta m < 1.0$).

In Fig. 2 selected CCD frames of visual double stars taken at ASV are presented. In the first row there are those obtained with the ST-10ME camera on June 18/19 2011. In the next two rows those obtained with Apogee Alta U42 on August 19/20 and October 20/21 and in the fourth row those obtained with the ST-10ME camera on November 2-4 2011. In the two last rows we present selected CCD frames obtained during 2012 with camera Apogee Alta U42 on April 22/23 and June 21-24. The selection of CCD frames followed the requirement to present both bright and faint pairs and also with large and small magnitude differences and with various separations. For each pair in its CCD frame the magnitudes and separation are given. The frames were measured by using AIP4WIN (version 2.3.1) software (Berry & Burnell 2002) and package IRAF (available at the official IRAF site).

The position angle and separation were measured for 303 double stars, in the case of the remaining 21, with separations less than $2''\!.0$, the star images were not visually separated and the measurements could not be carried out. The reasons are the proximity of the components and the limiting capabilities of the CCD cameras and the seeing for the corresponding night (see Table 1). Out of 324 double or multiple stars observed at ASV for 19 pairs the orbital elements have been calculated (announced), whereas in the case of 24 pairs a linear solution has been obtained. For these pairs we calculated the O-C residuals (in θ and ρ) from the corresponding ephemerides. All residuals are small which indicates that the results of our observations are good and that the orbital or linear solutions fit well also the recent measurements. We have prepared a paper which presents the measurements of relative coordinates and their analysis which will be published soon.

3. NEW OBSERVATION TECHNIQUES

The research team engaged in the study of visual double and multiple stars has a plan to use part of the funds obtained from the Ministry of Education, Science and Technological Development of the Republic of Serbia for the purpose of purchasing a high-speed CCD camera. The capabilities of such a camera allow read out frames with exposure times of the order of a few milliseconds. With it, with minimal additional funds, it would be possible to start immediately observations in which the lucky-imaging method is applied (see Kohl's paper in this volume). The lucky-imaging techniques use a high-speed camera with exposure times short enough so that the

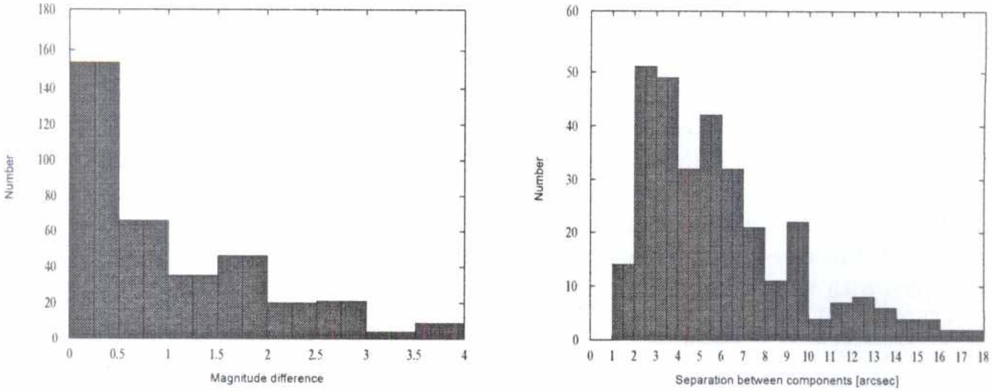


Figure 1: Frequency of the pairs of visual double or multiple stars versus: magnitude difference (left); separation (right).

turbulence in the Earth's atmosphere during the exposure is minimal. In the further procedure only the best frames are combined into a single image by shifting and adding the short exposures, yielding a much higher resolution than it would be possible with a single one with a long exposure time or a combination of all frames.

In addition to the camera it is also planned to get other components (optical system of mirrors and lenses for magnifying, filters) necessary for high-resolution speckle-interferometry observational techniques (Saha et al. 1999). This system would be mounted to a larger telescope, mirror of 1.5 m-class, in the process of purchase. The advantage of this approach is, certainly, the possibility to push the resolution limit towards its theoretical limit following from Rayleigh's criterion ($1.22\lambda/D$) which, in the case of our existing telescope ($D = 0.6$ m), is equal to $0''.23$, i.e. $0''.09$ for $\lambda = 550$ nm, in the case of the larger one ($D = 1.5$ m). With such an instrument and the corresponding equipment the members of our team will be able to measure much more very close pairs. This is very desirable because there are not many observatories in the world at which visual double stars are observed. "IAU Commission 26: Binary and Multiple Stars" has appealed to all observers, professional and amateurs, to observe regularly in order to enlarge the number of relative coordinates. Our plan is to continue the long tradition of observing double stars at the Belgrade Observatory, now using new techniques.

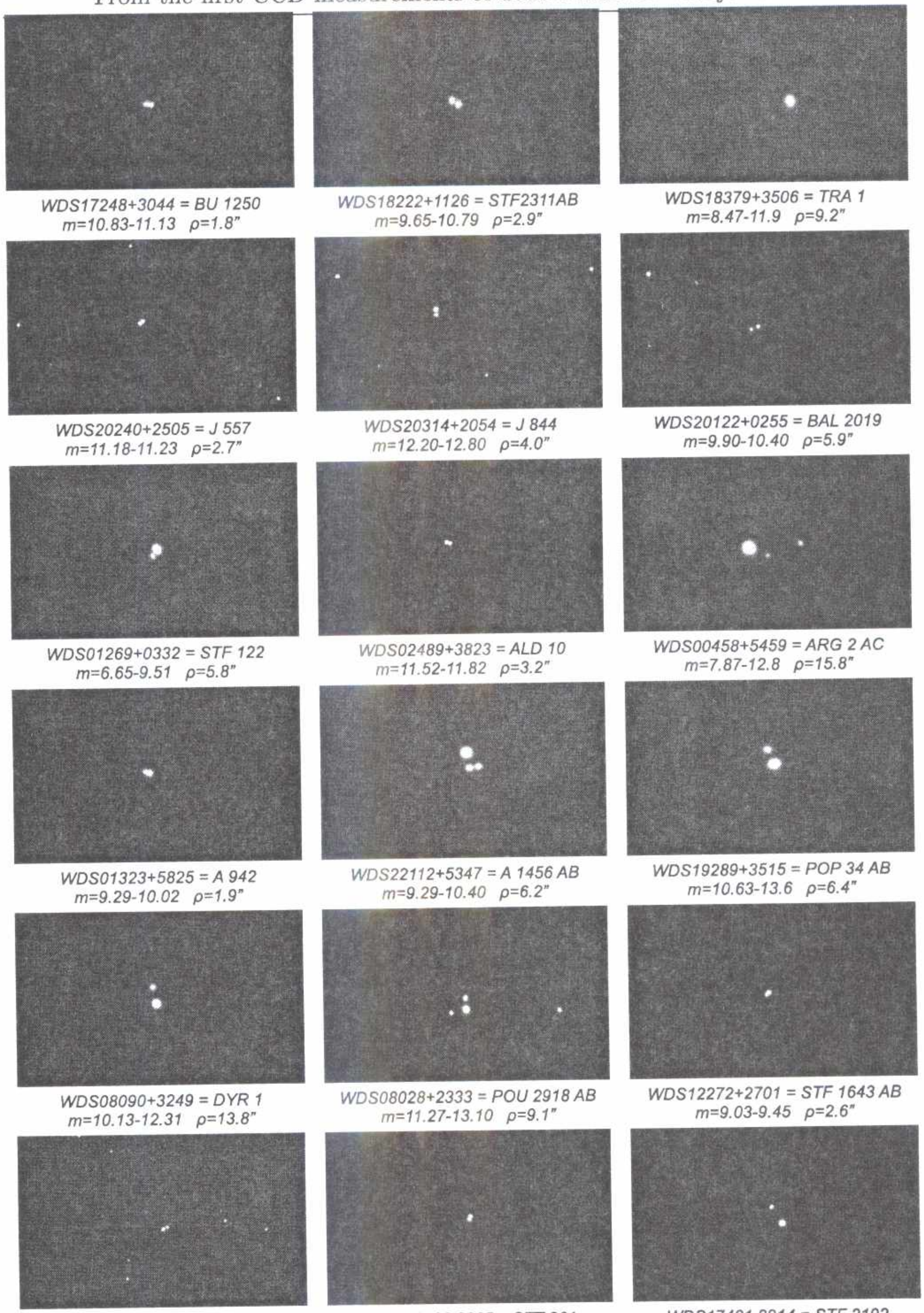
4. CONCLUSION

On the basis of the first series of CCD observations of double or multiple stars performed at ASV we can conclude the following:

1) out of 324 double stars, the relative coordinates of 303 were measured successfully;

2) the components were successfully resolved, i.e. separations greater than $1''.5$ were measured; pairs having smaller separations were not measured due to: telescope resolving power ($0''.23$), capabilities of the cameras and seeing (about $1''.5$);

3) the residuals from existing elements are small, a good confirmation of the high quality of our measurements;



WDS17248+3044 = BU 1250
m=10.83-11.13 ρ=1.8"

WDS18222+1126 = STF2311AB
m=9.65-10.79 ρ=2.9"

WDS18379+3506 = TRA 1
m=8.47-11.9 ρ=9.2"

WDS20240+2505 = J 557
m=11.18-11.23 ρ=2.7"

WDS20314+2054 = J 844
m=12.20-12.80 ρ=4.0"

WDS20122+0255 = BAL 2019
m=9.90-10.40 ρ=5.9"

WDS01269+0332 = STF 122
m=6.65-9.51 ρ=5.8"

WDS02489+3823 = ALD 10
m=11.52-11.82 ρ=3.2"

WDS00458+5459 = ARG 2 AC
m=7.87-12.8 ρ=15.8"

WDS01323+5825 = A 942
m=9.29-10.02 ρ=1.9"

WDS22112+5347 = A 1456 AB
m=9.29-10.40 ρ=6.2"

WDS19289+3515 = POP 34 AB
m=10.63-13.6 ρ=6.4"

WDS08090+3249 = DYR 1
m=10.13-12.31 ρ=13.8"

WDS08028+2333 = POU 2918 AB
m=11.27-13.10 ρ=9.1"

WDS12272+2701 = STF 1643 AB
m=9.03-9.45 ρ=2.6"

WDS18088 2450 = POU 3352
m=12.30-13.90 ρ=2.1"

WDS13120 3205 = STT 261
m=7.40-7.64 ρ=2.5"

WDS17401 2914 = STF 2192
m=7.82-10.49 ρ=15.3"

Figure 2: CCD frames of visual double or multiple stars obtained at Astronomical Station Vidojevica during 2011 and 2012 with two cameras ST-10ME and Apogee Alta U42.

4) we expect to achieve higher angular resolutions, under 1″ with lucky-imaging technique, i.e. even under $0\overset{''}{.}5$ with speckleinterferometry.

ACKNOWLEDGEMENTS. We used the Washington database maintained at the U.S. Naval Observatory and of the SIMBAD database, operated at CDS, Strasbourg, France. This research has been supported by the Ministry of Education, Science and Technological Development of the Republic of Serbia (Projects No 176011 "Dynamics and kinematics of celestial bodies and systems" and No 176021 "Visible and Invisible Matter in Nearby Galaxies: Theory and Observations").

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Publ. Astron. Obs. Belgrade No. 92 (2013), 83 - 84 *Contributed paper*

OPTICAL DETECTION OF THE EMISSION NEBULAE IN NEARBY GALAXIES

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Abstract. The standard way for the detection of emission nebulae in optical is by using photometric observations in narrow Hα filter. For this purpose in the most cases the 1.5 to 2 m telescopes are used. For the separation of supernova remnants (SNRs) from HII regions (including the planetary nebulae) the additional observations by using of narrow [SII] filter are necessary. If [SII]/H α ratio > 0.4 an observed nebula should be SNR. Here we present our observations of dwarf galaxies from M81 galaxy group (Holmberg IX, Arps loop) and of galaxy IC342 in order to detect new emission nebulae by using 2 m telescope of Rozhen observatory in Bulgaria. Our campaign started in 2007 and continues until now. In future, beside of Rozhen telescope, we plan to use new 1.5 m telescope, which will be mounted at the Astronomical Station of Vidojevica (ASV) for purpose of detection of new emission nebulae in nearby galaxies for the collecting of robust sample for the theoretical and statistical analyzes.

Presentation link: `http://belissima.aob.rs/Conf2012/Urosevic_2012.ppt`

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SEARCH FOR LENSED SUPERNOVAE BY MASSIVE GALAXY CLUSTERS WITH THE 2.5m NORDIC OPTICAL TELESCOPE

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Abstract. We shortly present here the ongoing project by the Stockholm supernova group about the search of high-z supernovae with the ALFOSC camera at the Nordic Optical Telescope by using galaxy clusters as gravitational telescope.

1. INTRODUCTION

Supernovae are one of the most energetic phenomena in the Universe, making them a useful tool in cosmology and astrophysics. There are several varieties, classified by distinct spectral characteristics (Minkowski, 1941). Here we focus on type Ia. These are thought to be caused by thermonuclear explosions on a white dwarf accreting material from a companion. There is some debate whether the companion is a white dwarf or a giant phase star (the so called single degenerate scenario, Nomoto et al. 1984) or a two merging white dwarfs (the double degenerate scenario, Iben and Tutukov 1984). Nevertheless, Ia supernovae are believed to be good *standard candles* by using the correlation between the light curve shape and the peak brightness (Philips 1993). As such, they played a crucial role in demonstrating the accelerating expansion of the Universe, thought to be caused by the enigmatic *dark energy* (Riess et al. 1998, Perlmutter et al. 1999).

A wealth of supernova Ia discoveries, coupled with measurements of the cosmic background radiation and the baryonic acoustic oscillations form the foundation of modern precision cosmology (for a review on supernova cosmology see Goobar, A. & B. Leibundgut, 2011). Despite the success of the field, there are still open questions. Observation of high-redshift supernovae would serve to answer some of these, shedding light on the evolution of dark energy and stellar metallicity. Furthermore detecting supernovae Ia at $z \geq 1.2$ could help to solve the progenitor problem, where the predicted supernova rate is sensitive to the different scenarios.

Pushing observation of supernovae to high redshifts is difficult simply because they are faint. The Hubble Space Telescope provides the bulk of recent high-z discoveries. Utilizing massive galaxy clusters as magnifying lenses (Gunnarsson & Goobar 2003) enables ground telescopes to contribute to the search. In this way, supernovae could be magnified up to 5 magnitudes (Stanishev et al., 2009 and Goobar et al., 2009).

In 2009 the pilot survey was performed with ISAAC instrument on the Very Large Telescope (VLT) where a core-collapse supernova at $z = 1.703$ was discovered behind A1689 with magnification of $\Delta m_{lens} = 1.58 \pm 0.07$ mag (Amanullah R. et al. 2011).

2. NOTCLULESS - CLUSTER LENSED SUPERNOVA SURVEY

The Nordic Optical Telescope (NOT) is located at the Observatorio del Roque de los Muchachos on the island of La Palma in the Canaries, Spain. The telescope is a Ritchey-Chretien Cassegrain with a primary mirror of 2.56 m and focal ratio of f/11. The Andalucia Faint Object Spectrograph and Camera, ALFOSC, is a back illuminated CCD with 2048 per 2048 pixels. ALFOSC has a field of view of 6.4' per 6.4' in imaging mode, and can also be used for low/medium resolution spectroscopy and polarimetry.

In April 2012 we started our monthly i-band monitoring program on the galaxy clusters A1689, A2218 and A2219 with the ALFOSC. This is an example how a high-z sources can be put within the reach of a 2.5 m telescope.

With the *POLOKA* reduction software, we match and stack contemporaneous (same night) images. The search for supernovae candidates is done by the subtraction of different nights. The calibration of the data has been done by using the SDSS catalogue as a reference. To check the reliability of the method, an efficiency test was performed by adding simulated supernovae into the data. We estimate that a magnitude of i=24 (Vega) would be necessary to detect a supernova on A1689 at S/N=5 with a one-hour observation. We expect to find around 10 SNe (both Ia and core collapse) during ESO periods. The current work focuses on performing photometry on each monthly stack to obtain the candidate light curves.

Our group has also two near-infrared ESO VLT ongoing programs called *Magnified view of high-z supernovae* where we use HAWKI to find lensed supernovae behind two massive galaxy clusters (A1689 and A370) and *Cherry Picked Supernovae: a Zoomed View of SN Ia and Dark energy* to perform photometric and spectroscopic follow-up of the candidates (PI: Goobar).

ACKNOWLEDGEMENTS. The author would like to acknowledge my supervisors Rahman Amanullah and Ariel Goobar, and also my colleagues Joel Johansson and Brandon Anderson.

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Publ. Astron. Obs. Belgrade No. 92 (2013), 87 - 88 *Invited lecture*

OBSERVATIONS AND MODELING OF STELLAR FLARES

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Abstract. We briefly review the current status of observations of stellar flares with meter-class telescopes and their relation to observations of flares on the Sun-as-a-star. Both stellar photometry and spectroscopy will be discussed. Solar and stellar flares are modeled using the methods of radiation hydrodynamics and we will make a summary of recent results.

Presentation link: `http://belissima.aob.rs/Conf2012/Heinzel_2012.pptx`

Networked Telescopes, Networked Science

Publ. Astron. Obs. Belgrade No. 92 (2013), 91 - 92 *Invited lecture*

LCOGT: A WORLD-WIDE NETWORK OF ROBOTIC TELESCOPES

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Abstract. Las Cumbres Observatory Global Telescope (LCOGT) is an organization dedicated to time-domain astronomy. To carry out the necessary observations in fields such as supernovae, extrasolar planets, small solar-system bodies, and pulsating stars, we have developed and are now deploying a set of robotic optical telescopes at sites around the globe. In this talk I will concentrate on the core of this network, consisting of up to 15 identical 1m telescopes deployed across multiple sites in both the northern and southern hemispheres. I will summarize the technical and performance aspect of these telescopes, including both their imaging and their anticipated spectroscopic capabilities. But I will also delve into the network organization, including communication among telescopes (to assure that observations are properly carried out), interactions among the institutions and scientists who will use the network (to optimize the scientific returns), and our funding model (which until now has relied entirely on one private donor, but will soon require funding from outside sources, if the full potential of the network is to be achieved).

Presentation link: `http://belissima.aob.rs/Conf2012/Brown_2012.ppt`

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RESULTS AND PERSPECTIVES OF THE MASTER ROBOTIC TELESCOPES NETWORK

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Abstract. The MASTER Net of Mobile AStronomical TElescopes-Robots has been developed since 2002 and started its fully autonomous operation in March, 2011. At the moment it consists of five identical binocular telescopes with a total of ten 0.4-m tubes corresponding to the effective aperture of 1.25 m. They are situated in five locations spread over six time zones, from 127E longitude in Russian Far East to 37E in the Central European part of Russia (see `http://observ.pereplet.ru` for more details). Originally designed for the fast response to Gamma-Ray Burst alerts from the spacecrafts, the telescopes of MASTER Net are discovering a lot of new objects in the survey mode, including a number of astrophysically important ones. In the first year of full time operation MASTER robotic telescopes have discovered more than 120 optical transients, including over 50 supernovae candidates, about 30 new cataclysmic variables, classical Nova, several fast transients and objects of unknown nature. In the same time MASTER telescopes keep on providing about 50 per cent of the first pointings to the GRB alerts in the world, including the observations from space. The plans are to install two to four additional MASTER systems abroad (on the Canary Islands, in Argentina, South Africa and Antarctica) to cover the western hemisphere and the southern sky. Using the identical instruments will allow the unique continuous monitoring of the sky covering about 5000 sq. deg. per night to the 20th limiting magnitude.

Presentation link: `http://belissima.aob.rs/Conf2012/Denisenko_2012.ppt`

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THE 2012 AE AQR MULTIWAVELEGTH CAMPAIGNS

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Abstract. Results from a multiwavelength campaign on the Cataclysmic Variable star consisting of the fastest spinning white dwarf with a frequency of 33s will be presented. The campaign was undertaken by simultaneous observation of ground (optical and TeV) and space (X-ray) observatories.

Presentation link: `http://belissima.aob.rs/Conf2012/Ioannou_2012.ppt`

Publl. Astron. Obs. Belgrade No. 92 (2013), 97 - 98 *Invited lecture*

EXPLORATION OF THE TIME DOMAIN

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Abstract. Synoptic sky surveys are becoming the largest data generators in astronomy, and they are opening a new research frontier, that touches essentially every field of astronomy. Opening of the time domain to a systematic exploration will strengthen our understanding of a number of interesting known phenomena, and may lead to the discoveries of as yet unknown ones. Time domain astronomy is inherently astronomy of telescope and computational systems, where small telescopes can do big science.

Presentation link: `http://belissima.aob.rs/Conf2012/Djorgovski_2012.pdf`

Publl. Astron. Obs. Belgrade No. 92 (2013), 99 - 104 *Contributed paper*

DEVELOPING A TELESCOPE SIMULATOR TOWARDS A GLOBAL AUTONOMOUS ROBOTIC TELESCOPE NETWORK

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Abstract. A robotic telescope network is a system that integrates a number of telescopes to observe a variety of astronomical targets without being operated by a human. This system autonomously selects and observes targets in accordance to an optimized target. It dynamically allocates telescope resources depending on the observation requests, specifications of the telescopes, target visibility, meteorological conditions, daylight, location restrictions and availability and many other factors. In this paper, we introduce a telescope simulator, which can control a telescope to a desired position in order to observe a specific object. The system includes a Client Module, a Server Module, and a Dynamic Scheduler module. We make use and integrate a number of open source software to simulate the movement of a robotic telescope, the telescope characteristics, the observational data and weather conditions in order to test and optimize our system.

1. INTRODUCTION

A robotic telescope is an astronomical telescope that can observe the universe without being operated by a human (Wang et al. 2006). A robotic telescope system typically incorporates a number of subsystems, including a detector driving system (telescope pointing capability and dome control), focusing control system, weather station, etc. For an accurate observation and to maximize data collection the coordination of all these subsystems is essential. Moreover, as there is always an observation error introduced by a human operator, the autonomous robotic telescope can easily provide a more accurate observation with much higher efficiency. Furthermore, a single robotic telescope (regardless of its technical character, and construction cost) is limited by a number of constraints, such as telescope specification, target visibility, meteorological conditions, daylight, location restrictions, telescope availability etc.

A robotic telescope network normally consists of a number of robotic telescopes, preferably spaced over long distances in order to overcome location induced limitations. Based on the coordination of the sub robotic telescopes, the telescope network can be treated as a single observing instrument. Our final objective is to develop a system that is capable to manage and control a global robotic telescope network.

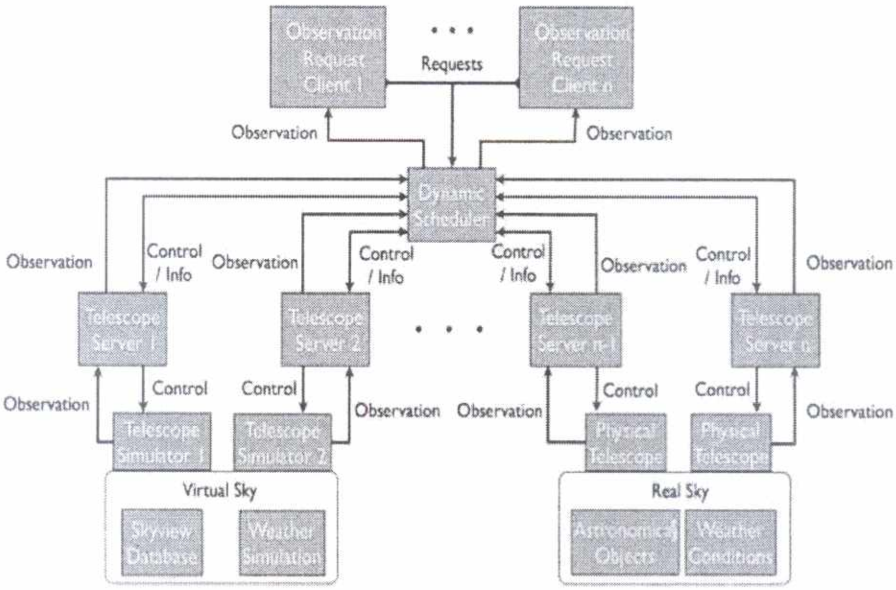

Figure 1: System architecture diagram

The robotic telescope network can be seen as a distributed sensor network with optimal estimation. It integrates the observation information from each robotic telescope. Currently there are a number of robotic telescope networks operating a wide range of telescope sizes and types (ROTSE, WET, HATNet, Robonet, Monet, LCGOT) with various degrees of human interaction involved in their operation.

Distributed sensor networks have been researched for many years (Garcia 2011). Nowadays, they have been successfully applied in forest fire detection (Ma et al. 2008), volcanoes monitoring (Werner-Allen et al. 2006), ocean measurements (Vasilescu et al. 2005), etc. While for the optimal estimation, we have many choices, like Kalman Filtering (Ribeiro et al. 2010), Information Filtering (Olfati-Saber & Shamma 2005), Viener Filtering (Kumar, Altman & Basar 2012), etc. However, the gap between the distributed sensor (i.e., single robotic telescope) for automatic optimal estimation is the information fusion. There are many kinds of robotic telescopes and each telescope's working condition is different. Here, we focus on how to combine these robotic telescope systems together. As a first step, we create a telescope simulator to act as a platform on which we will test our system

2. SYSTEM ARCHITECTURE

The proposed system that is able to manage and control the theoretical global robotic telescope network consists of three major sub-modules: a Client Module, a Server Module, and a Dynamic Scheduler Module (see Figure 1).

The following is a brief description of how the system architecture is implemented. First of all, an observation request is sent by the Client Module to the Dynamic

Scheduler Module. Then, the Dynamic Scheduler Module decides the available robotic telescopes for this specific observation request by considering the specifications of each of the telescopes, the target visibility at each telescope location, the meteorological conditions, etc. Afterwards, the Dynamic Scheduler Module communicates with the Server Module of each telescope and receives their current status. Once it finds the specific telescope that meets all the preconditions it then sends the command to the Server Module of the telescope to start the observation procedure. Later, once the telescope is on the desired position and has collected the observational data, the server module sends back to the Dynamic Scheduler Module the observational data. Finally, the Dynamic Scheduler Module forwards the observation data received from the Server Module to the Client module.

2. 1. THE CLIENT MODULE

The Client module is an application designed using the programming environment of *Labview*. It has as purpose to be the main User Interface (UI) of each client connected on the telescope network as well as the application, which can provide the observational data from the telescope (Feedback). The Client module is able to get inputs through user interface about all the necessary parameters for an observation, such as: target coordinates (declination, right ascension), desired date and time of observation, observation time, etc. When the user gives all the necessary parameters for an observation request to the Client Module following a start command, the Client Module software starts a TCP communication to the Dynamic Scheduler Module and sends all the above observation request data. The outputs of the Client module include the TCP communication data mentioned above, the real time information of the telescope (telescope position, weather condition, telescope specifications, site information, etc.) and the observational data. The algorithm of Client Module calculates the data from the user interface which is in string format, and then create bigger string containing all the data from the observation request in addition to some other data. This new-created data assists the Dynamic Scheduler Module algorithm to separate the useful information and to convert them into numeric values for further processing. After the data packet is ready, the Client Module opens a predefined network port and sends the data packet to specific IP address and port in a TCP protocol. In order to make our system more reliable, when Client Module sends the data, it leaves the same port open and wait to receive an announcement from Dynamic Scheduler Module successfully. We also add text to speech features to the Client Module in order to make a user-friendlier environment, by calling .NET classes from Windows operating system.

2. 2. THE SERVER MODULE

The Server module is an application designed using the programming environment of *Labview* and has a purpose to receive commands from the Dynamic Scheduler, to control the actual physical telescope, to send telescope status information to the Dynamic Scheduler and finally to send the Observation Data to the Client module. The Server Module is connected to the physical hardware of the telescope by using the AStronomy Common Object Model (ASCOM) driver libraries. The communication with the telescope hardware is bidirectional, which means that the Server module can give control commands to the telescope or to other instruments which are connected to the telescopes, such as cameras, filter focusers, filter wheels, domes, rotators, etc.

In addition, it receives current information for their status, such as telescope position, weather conditions, site information, dome position, selected filter, etc.

The Server Module as inputs all the necessary parameters to conduct an observation, such as, the target coordinates (Declination, Right Ascension), desired filter, etc. The inputs are made through a user interface (local control) or through a network by using TCP communication protocol (remote control). The outputs of the Server Module are the physical communication with the telescope hardware as we mentioned above. The information of the hardware state is transferred through user interface (local feedback) or through the network (remote feedback). The observation data is also transferred through user interface or through the network. To incorporate the ASCOM libraries to our software, we call .NET classes from the ASCOM open source code.

The Server Module algorithm has two operation modes: the local operation mode, and the remote operation mode. When the Server Module algorithm works on local mode, it takes the inputs values from the user interface fields and after some numeric transformations and calculation, it passes the results to the .NET classes of ASCOM libraries which communicate directly to the telescope hardware. Also, when the Server Module sends the slew command to the telescope, it tracks the telescope movement every 100 ms to make sure that the telescope moves to the right position. When the desire position is reached, it informs the user through the user interface that the telescope is on the desired position. When the Server module runs on remote mode, it opens a specific network port and waits to receive the data from the Dynamic Scheduler which contains the necessaries values to control the telescope. If the values are received successfully, it starts the same procedure described above to drive the telescope to the desired position. Meanwhile, it sends back to the Dynamic Scheduler module an announcement that the data has been received successfully. When the telescope is executing a movement the Server Module sends to the Dynamic Scheduler the current position of the telescope every 200 ms. For all the remote communication with the Dynamic Scheduler, the Server module sends and receives data by using the TCP protocol.

2. 3. THE DYNAMIC SCHEDULER MODULE

The Dynamic Scheduler Module is an application designed using the *Matlab* software package. Its purpose is to receive observation requests from the multiple Client Modules. By considering all the necessary parameters, it decides which telescope is appropriate for each observation request and makes the connection between the Client Module and the Server module.

We are experimenting with a host of scheduling algorithms at this stage. The incoming observation requests are partially specified, allowing for flexibility in their allocation; for example, a total observation duration might be specified, but within a flexible time window, and with the possibility for breaking the observation time to a number of sub-segments, which add up to the total required time. Most importantly, the scheduler might dynamically reschedule the observation in real time, given changing weather conditions or technical failures which necessitate the reallocation of observations that were assigned to telescopes which are now unavailable.

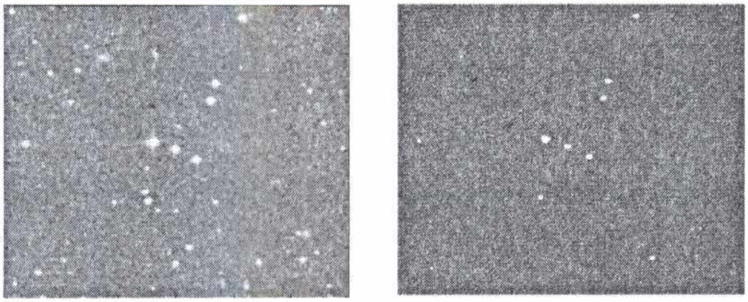

Figure 2: Image processing for adjusting observation images. Before adjustment (Left), after adjustment (Right)

3. THE SIMULATOR

To fully test our system and make the required experiments and optimization, we add some simulation features in our software. Those features include telescope movement, observation and observation image adjustment.

3. 1. TELESCOPE MOVEMENT

The simulation of the telescope movement is built using open source software. The open source software *Stellarium* is used to simulate the telescope movement and visualize the telescope pointing on the sky. When the Server Module receives the slew command and sends this command to the robotic telescope, the simulator receives back the actual position of the telescope every 100 ms until the telescope arrives at the desired position. When the Server Module receives a new position of the telescope, it transfers a value to the Stellarium software by using the UDP protocol.

3. 2. OBSERVATIONS

To be able to simulate the observation data we use the Digital Sky Survey (DSS) database from the *SkyView Virtual Observatory* by incorporating the *SkyView* Java interface into our Client Module. When the Client module receives that the virtual telescope is on the desired position, it runs an open source Java script code, which has access to the database of DSS images and retrieves the hypothetical observation data from the specific position of the simulated telescope. The retrieved images are FITS type images.

3. 3. OBSERVATION IMAGE ADJUSTMENT

To be able to simulate the effects of weather and sky conditions to the simulated sky images, we employ Gaussian filtering as well as artificial noise floor modulation, in order to create adjusted images, which correspond to what we would expect to have seen from the sky given specific telescope characteristics. An example set of images can be seen in Figure 2.

4. CONCLUSIONS AND FUTURE WORK

In this paper, a simulator was developed. It has the function of positioning to a desired target based on the client request. In the future we plan to implement a simulation of real time weather conditions in addition to real time data reduction, data quality evaluation and real time object classification on every acquired image with the final goal being to test the system on a real life telescope network.

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Education and Public Outreach

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ASTRONOMY EDUCATION AND POPULARIZATION IN SERBIA

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Abstract. Astronomy education at all levels (elementary and secondary schools, universities) in Serbia is reviewed. The attempts to introduce astronomy as an elective course in elementary schools and to reintroduce astronomy as a separate subject in secondary schools are discussed. The role of the Petnica Science Center is briefly described, as well as the participation of the Serbian team in the International Astronomy Olympiads. A special emphasis is put on recent changes introduced in the accredited study programs at all five Serbian state universities. The research projects performed in two main astronomical institutions in Serbia are outlined. The numerous amateur astronomical societies in Serbia are presented and their growing activities summarized.

1. INTRODUCTION

Astronomy education and research in Serbia have tradition of almost 130 years. In this paper the most important activities are summarized that take place in Serbia in all five fundamental aspects of astronomy development: primary, secondary and tertiary education, research and science public outreach.

2. PRIMARY AND SECONDARY SCHOOLS

The beauty of the sky, the cosmic objects and the immensity of the Universe are inspirational for everyone, but especially for children. The Universe fascinates young children and stimulates their imagination. Due to this fact astronomy is one of the most attractive sciences and an excellent tool for introducing science and technology to children. Moreover, as the early years are crucial in the development of the human values system, the immensity of the Universe provides a perspective encouraging internationalism and tolerance.

In the elementary schools in Serbia astronomy topics are taught as part of the courses of Natural History, Geography and Physics. As astronomical studies have led to new discoveries in chemistry and biology and to the development of the new sciences of astrochemistry and astrobiology, astronomy topics could be integrated into the courses of chemistry and biology as well. Within the recent reform of primary school education, several astronomy lectures have been introduced as extra topics in the 7th and 8th year physics course curricula. Since the science education at the younger age is crucial for developing scientific literacy among the general population and having in mind a unique role astronomy plays in facilitating education, astronomers in Serbia are trying to introduce astronomy as a separate and elective subject in the elementary school curricula.

In the secondary schools astronomy topics are incorporated within the final (4^{th}) year physics courses. However, as the physics teachers often neglect astronomy topics, the astronomical community has made many efforts to reintroduce astronomy as a separate subject. Namely, for 25 years (1969-1994) astronomy was taught as a separate and compulsory course. However, in 1990 it was incorporated within the course of Physics. Since then astronomy is taught as a separate course only in the Mathematical High School of Belgrade and in a couple of high schools in Serbia.

2. 1. PETNICA SCIENCE CENTER

Petnica Science Center (PSC), located near Valjevo, some 100 km from Belgrade, is the biggest and the oldest center for extracurricular (informal) education in South Eastern Europe (`http://www.ispast.net`, `http://pi.petnica.rs`). Its main concept is *learning through research.* PSC programs give the gifted students an intensive extracurricular education and enable them to carry out scientific projects under the supervision of scientists and science teachers.

Since its foundation in 1982 Petnica has organized more than 2,500 programs (seminars, workshops, research camps, ...) for students and science teachers in 15 disciplines of science, technology and humanities. Majority of programs are designed for secondary-school students although there are a lot of programs for primary-school pupils, university students and science teachers.

The PSC organizes two cycles of seminars in astronomy consisting of 4 seminars per year. Each seminar is attended by about 25 participants and lasts 7-8 days on the average. The cycle "Astronomy 1" is of educational character as it is intended for the participants attending the PSC astronomy seminar for the first time. Participants of the second cycle "Astronomy 2" work on their independent observational/research projects, and the seminars of the second cycle are intended to support their work. The best research projects are presented at the Conferences of the PSC participants "A step into science" and published in "Petničke sveske" ("Petnica notebooks").

2. 2. INTERNATIONAL ASTRONOMY OLYMPIADS (IAO AND IOAA)

In 2002 Professor J. Milogradov-Turin (Milogradov-Turin 2003), then the president of the Society of Astronomers of Serbia (SAS), initiated the participation of Serbia in the International Astronomy Olympiad (IAO). Since 2004 the National Astronomical Olympic Committee (NAOC) has been in charge of training, testing and selection of the national team.

Serbian teams participate at two International astronomy olympiads: since 2002 at IAO (founded in Russia in 1996) and since 2007 at IOAA (International Olympiad on Astronomy and Astrophysics, founded on the initiative of Tailand, Indonesia, Iran, China and Poland in 2007). In the past 11 years Serbian teams (57 participants in total) participated at 9 IAO and 4 IOAA olympiads and won 6 gold, 14 silver and 22 bronze medals, as well as 2 special prizes and 4 recognitions.

3. UNIVERSITY EDUCATION AND RESEARCH

Teaching of mathematics and physics in Serbia started in 1838 at Licej, which was transformed to Velika škola (the Grand School) in 1863. Astronomy teaching was introduced at the Grand School in 1884 when Milan Nedeljković, founder and the first director of the Astronomical and Meteorological Observatory of Belgrade, was elected professor for the courses of astronomy and meteorology. The Department of Astronomy now belongs to the Faculty of Mathematics of the University of Belgrade (for a detailed history of the Department/Chair of Astronomy see the review by Simovljević and Milogradov-Turin, 1998).

At present astronomy courses are taught at five state universities in Serbia: University of Belgrade, University of Novi Sad, University of Niš, University of Kragujevac and University of Priština in Kosovska Mitrovica. In 2005, the European Credit Transfer System (ECTS) is introduced and within the past three years the studies have been accredited at all state universities in Serbia.

Since the textbook "Nebeska mehanika" ("Celestial mechanics") written in 1935 by Professor Milutin Milanković, well known for his astronomical theory of climate, more than 20 university textbooks in astronomy and astrophysics written by professors of Serbian universities have been published.

3. 1. UNIVERSITY OF BELGRADE

At the University of Belgrade since early 1960's students can major in Astronomy and Astrophysics from the first study year. Apart from the courses in mathematics and physics they follow about 15 one-semester courses of astronomy and astrophysics. So far, 271 students have graduated from the Department of Astronomy, Faculty of Mathematics, University of Belgrade (46% of which are women), 69 students received MSc degree (39% women) and 41 students received PhD degree (27% women).

Since 2006/2007 academic year study programs of Astronomy and Astrophysics have been adjusted to the new ECTS. Model 4+1 for the first two degrees (bachelor in astronomy and master astronomer) was accepted. So far 18 students received master degree (61% women). In 2009/2010 the studies were accredited. New accredited study program "Astronomy and Astrophysics" consists of 3 programs (Computational mechanics and astrodynamics, Astrophysics, Astroinformatics) at undergraduate (4 years) level, 2 study programs (Astronomy, Astrophysics) at Master studies and one study program (Astronomy and Astrophysics) at PhD studies. Master programs contain 7+7 elective courses in astronomy and astrophysics, whereas 33 elective courses are offered at the PhD level.

Since 2011/2012 the Faculty of Mathematics participates in "AstroMundus", a 2-year master program in astronomy and astrophysics in the framework of the ERASMUS MUNDUS Programme of the EU (5 universities are included: Innsbruck (coordinator), Rome, Padova, Gottingen and Belgrade).

The Department of Astronomy organizes regular seminars on different topics in astronomy every second Tuesday during the academic year, the International summer schools in astronomy and astrophysics (2007, 2008, 2010) and Astronomy Students

Workshops (since 2007) together with the Department of Physics in Novi Sad and Astronomical Observatory in Belgrade, aimed at improving contacts between the students of astronomy from Belgrade and Novi Sad.

Apart from the above mentioned, at the Faculty of Mathematics astronomy is also taught either as compulsory course (for the students of mathematics and informatics teachers division) or as an elective course for all the students of Mathematics and Informatics. At the Faculty of Physics there is a compulsory one-semester course at master studies for physics teachers division, and an elective one-semester course for the students at undergraduate level. At the Faculty of Civil Engineering, a compulsory course of geodetic astronomy is taught.

3. 2. UNIVERSITY OF NOVI SAD

Since 2002/2003 academic year the Department of Physics of the Faculty of Natural Sciences at the University of Novi Sad has founded the astronomy study group, introducing simultaneously the European Credit Transfer System. First the model 3+1+1 was accepted. Since 2008/2009 new accredited studies are of the model 3+2. Up to now 18 students got 3-years diploma, 8 students got 4-years diploma and 3 students got master degree. Astronomy and astrophysics are also taught within one-semester elective courses to the students of other study programs at the Department of Physics.

3. 3. UNIVERSITIES OF KRAGUJEVAC, NIŠ AND KOSOVSKA MITROVICA

There are one-semester compulsory courses of astronomy for the students of physics at the Universities of Kragujevac, Niš and Kosovska Mitrovica, while several elective astronomy courses are taught at the Departments of Physics, Biology and Geography of the University of Niš.

3. 4. SUMMER PRACTICE / TRAINING IN OBSERVATIONS

Since 2007 the students of the Universities of Belgrade and Novi Sad have 3-weeks summer practice in observations and data reduction at the Ondrejov Observatory (Czech Republic). The students are included in research at the following four departments: Stellar department (physics of hot stars), Solar physics department (solar flares and prominences), Department for interplanetary matter (asteroids) and Department for galaxies and planetary systems. As of recently they are using also the facilities (60 cm reflector) of the Astronomical Station at mountain Vidojevica.

3. 5. RESEARCH IN ASTRONOMY

Astronomy research in Serbia is mainly performed in two astronomical institutions: Astronomical Observatory of Belgrade (AOB, founded in 1887, 42 researchers) and the Department of Astronomy, Faculty of Mathematics, University of Belgrade (15 researchers). With researchers from the Institutes of Physics (Zemun and Vinča), Universities of Novi Sad, Kragujevac and Niš, there are about 70 researchers in astronomy in Serbia and about as many in abroad. The researchers participate in 9 scientific projects financed by the Ministry of Education and Science of Serbia and in several international cooperations and projects (SREAC, VAMDC, Belissima, Astromundus, LSST). The researchers of the Astronomical Observatory participate in the undergraduate study programs at the University of Novi Sad, as well as in the Master and PhD study programs of Astronomy and Astrophysics at the Belgrade University.

Main research topics are: (a) Astrometry and dynamical astronomy: Earth rotation, Solar system dynamics, Celestial mechanics, Double stars, Stellar systems dynamics; (b) Astrophysics: Astrophysical spectroscopy, Solar physics, Radiative transfer, Close binary stars, Stellar kinematics and dynamics, Interstellar medium, Supernova remnants, Galactic astronomy, Extragalactic astronomy (AGN, gravitational lensing), Cosmology; (c) Astrobiology; (d) Astroinformatics and (e) History of astronomy. For more on the history of AOB and of its research activities see Atanacković-Vukmanović (2007).

The largest telescope in Serbia is still a refractor Zeiss 650/10550 mm at AOB. Purchase of a 1.5m class telescope is in progress. It will be mounted at the same site as 60 cm telescope on Vidojevica mountain in the next couple of years.

The Astronomical Observatory and the Department of Astronomy publish together *Serbian Astronomical Journal* (`http://saj.matf.bg.ac.rs`). Also, every three years these two institutions organize National conferences of astronomers of Serbia (NCAS) with more than 100 participants and about 10 guests from abroad. The proceedings of the Conference are published in the *Publications of the Astronomical Observatory of Belgrade.*

4. PUBLIC OUTREACH

Astronomy is the most attractive of all sciences for the general public. As a unique combination of science, technology and culture, astronomy continues to play an important role in modern society. In Serbia it receives much more attention in the newspapers and other media than the other sciences. Yet, public astronomy education in Serbia is mainly realized through various activities (public observations of astronomical events, lectures to elementary/secondary school students and the general public in two Planetaria (Belgrade and Novi Sad), courses, conferences, schools and camps) of 20 amateur astronomical societies (see Table 2 in Atanacković, 2012).

In January 2010 the Association of astronomical societies and astronomical sections of Vojvodina was founded. Also, the Amateur Astronomers Association of Serbia (SAAS, `http://www.saasr.org`) was founded in February 2010 with the aim to include all astronomical societies in Serbia in popularizing astronomy and related sciences by organizing camps, lectures, observations etc. all over Serbia. A nice example of an intensive collaboration among the amateur societies is Letenka camp organized every year on the mountain Fruška gora.

The common problem of all amateur societies is lack of adequate space, equipment and financial support. They usually manage to survive thanks to enormous enthusiasm and the hard work of their members, often consisting of only a few people.

Many amateur astronomical societies have their web sites. More details about their activities can be found in the journals/magazines they publish: *Vasiona* (*The Universe*, since 1952); *Astronomija* (2003-2009); the internet magazine "Astronomical magazine" - the largest astronomical web site (`http://www.astronomija.co.rs`) in the country, maintained by the AS "Lyra" of Novi Sad since 1998; annual bulletins *Gea*, etc.

The societies took part in the popularization of astronomy through local TV and radio programs, newspapers and web portals. They participate in some special events (Night of Museums, at national and international conferences, Book Fairs, Education

Fair "Bell", Festivals of Science, International Year of Astronomy etc.). Majority of societies organize regular courses/schools of astronomy for the beginners.

The most popular events organized by astronomical societies in Serbia are:

- *Belgrade Astronomical Weekends* and *Summer Astronomical Meetings* organized by the largest and the oldest society of amateur astronomers - AS "Rudjer Bošković" situated within the Kalemegdan fortress in Belgrade; the Society organizes also Summer Schools of Astronomy often together with other astronomical societies;
- *international astronomical camps "Letenka"* lasting four days in July and observation competition in *the Messier marathon* early in spring at Letenka, both organized by AS "Lira";
- *Astronomical Meetings of Vršac* (Astronomical Group of "Gea" Society);
- *Niš astronomical meetings* (AS "Alfa");
- the exhibitions of astrophotographs (AS "Univerzum");
- astronomical camps in Sivčina near Ivanjica (AS "Orion"), and in Deliblatska peščara (AS "Milutin Milanković", Pančevo).

More details about the recent activities of the amateur astronomical societies can be found in Atanacković (2012).

5. CONCLUDING REMARKS

Serbia is an IAU member state with 41 individual members. According to the classification scheme given in the IAU Strategic Plan, Serbia belongs to the Group 1B of developed astronomy research countries with fewer than 4 members per million inhabitants, that participate in, or host, frontline astronomy research facilities. It is also the country with high education index of about 0.8 (education index is $E = (2/3)L + (1/3)C$, where L is literacy rate and C is combined gross school enrolment ratio).

The main goals in astronomy education and popularization in Serbia are the following:

- reintroduction of astronomy as a separate subject in the school curricula
- education of teachers through courses, seminars and workshops
- training best pupils for the astronomical olympiads
- strengthening of relations with other universities in the SEE region and worldwide (twinning between universities), and
- intensification of the public education in astronomy via lectures, articles, radio and TV programs.

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ASTROINFORMATICS, VIRTUAL OBSERVATORY AND WEB 2.0

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Abstract. In the last ten years the huge development in sensor and ITC technologies has revolutionized the operational framework of observational astronomy. The size and complexity of modern astronomical data sets require in fact the interoperability of data centers and data archives as well the possibility for the average user to access large computational facilities. The Virtual Observatory has largely solved most of the problems related to data interoperability and has also provided the community with a wealth of tools capable to effectively deal with a distributed data environment. Much work, however, remains still to be done since the limitations of the network infrastructures pose strong constrains on the way data can be processed since Multi-Terabyte of data cannot be easily moved. This problem can be in part circumvented by moving applications rather than the data.

Presentation link: `not available`

Celebrating 125 Years of the Astronomical Observatory

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AGB STARS IN GALAXIES: C AND M IDENTIFICATION

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Abstract. The AGB branch is made essentially of two types of stars characterized by different chemical surface abundances, namely C stars (carbon rich) and M stars (oxygen rich). Distinguishing C and M stars is trivial on the basis of spectroscopic data. However, objective-prism spectroscopy is limited to the Magellanic Clouds and therefore several alternatives have been proposed over the years to reach further away in the Local Group.

The adoption of narrow-band photometric filters centered on characteristic spectral features was the first, quite successful, "next step" beyond the objective prism spectra.

All the major existing and future telescopes are optimized for near-infrared (near-IR) photometry and thus several authors have attemped to tell apart AGB C and M stars from near-IR data only.

In this paper, near-IR alone and "combined" near-IR plus narrow-band photometric selection methods are investigated, discussed and their usefulness assessed.

1. INTRODUCTION

The beginning of the Asymptotic Giant Branch's history is difficult to establish. Certainly, the discovery by Secchi of a new class of stars that did fit none of the three classes of his spectral classification, marks an important point that nowadays we would say is the distinction between M- and C-type stars.

In 1868, Secchi announced the existence of a very rare kind of red stars, he classified them into Class IV, similar in colour to Class III (orange to red stars) but with clearly different spectral features. Since the beginning, Secchi correctly realized the reason of such unusual spectral features, namely the chemical composition of the stellar atmosphere: "The two spectra [class III and IV] are not merely modification of the same type, they are evidently due to completely different substances. ... there is a marked analogy with the reverse spectrum of carbon" (Secchi, 1868). These stars are what we now refer as to "carbon" stars.

It took about a century to reach a satisfactory understanding of carbon stars. In the early 70's, Iben & Rood (1970) proposed the term "Asymptotic Giant Branch" (hereafter AGB) as a post horizontal giant branch phase characterized by a double-shell burning source and later on Iben (1974) explained the presence of carbon in the spectra of some AGB stars as a result of the "third" dredge-up process. This process, occurring during the thermally pulsating asymptotic giant branch (TPAGB) phase, carries to the stellar surface the ^{12}C synthesized in the helium-flash convection zone as well as s-process elements synthesized both during the inter-flash phase and during the flash phase.

Since the beginning, the term carbon stars was related to the presence of an over-abundance of carbon on the surface as determined by direct spectroscopic observations. However, the dredge-up process is not the only possible way to produce a star with an excess of carbon on its surface: an exhaustive description of different kinds of carbon stars can be found for instance in Wallerstein & Knapp (1998). Even though we will consider in this paper only the C N-type stars, i.e. the genuine AGB C stars, one must be aware of the existence of non-AGB C stars that can pollute the observed sample of AGB C stars, see Fig. 2 for example.

Another important aspect in the study of C stars is the shift, that occurred over the years, in the identification methods from single-star spectroscopy, to narrow-band photometry, near-IR and recently IR from the space. This dramatically extended our study of C stars but, at the same time, made it clear that the samples of C stars identified depend on the identification method adopted.

The narrow-band technique was developed in the 1980's. It requires photometric observations with four filters: two standard filters such as R and I or V and I and two narrow-band filters called CN and TiO centered at 808.6 nm and 768.9 nm. The R filter is preferable to the V filter because the red AGB's are one magnitude brighter in R than in V. Figure 1 shows an example of a colour-colour diagram, this one in for the Local Group galaxy Wolf-Lundmark-Melotte (Battinelli & Demers 2004). The vertical limit of the boxes, is set at $(R-I)_0 = 0.90$ this corresponds to the colour of stars of spectral type M0. The horizontal limits are set arbitrarily, between the two limits we expect to find stars of spectral type S. Since narrow-band filters are expensive and not available for most telescopes, people have turned to near infrared photometry. This approach is not really fully proven. Figure 2 presents a colour-magnitude diagram of the spectroscopically identified carbon stars in the Small Magellanic Cloud, from Demers et al. (2002). We see that C stars have quite a range in magnitude and colour. The cool N-type are found in the box.

In the literature there are several papers which compare the various methods: near-IR and narrow-band are compared by Battinelli & Demers (2007,2009); far-IR compared to narrow-band by Jackson et al. (2007), Matsuura et al. (2009) and Boyer et al. (2011). A discussion of this aspect is given in Battinelli & Demers (2011). Today's large telescopes – and even more tomorrow's ones – operate most efficiently in the near-IR making this approach the more suited for the study of AGB population in galaxies beyond the Local Group. Unfortunately, nowadays, different authors using near-IR very often adopt different selection criteria (e.g. different colour thresholds, CMD or two-colour diagram selections etc.). It is therefore of pivotal importance to dispose of a reliable "standard" near-IR identification technique for C and M stars.

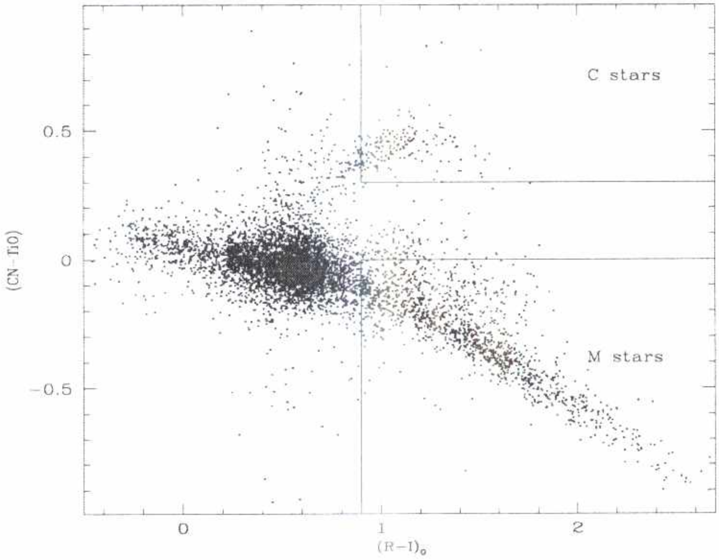

Figure 1: Example of the selection of C stars from narrow-band technique.

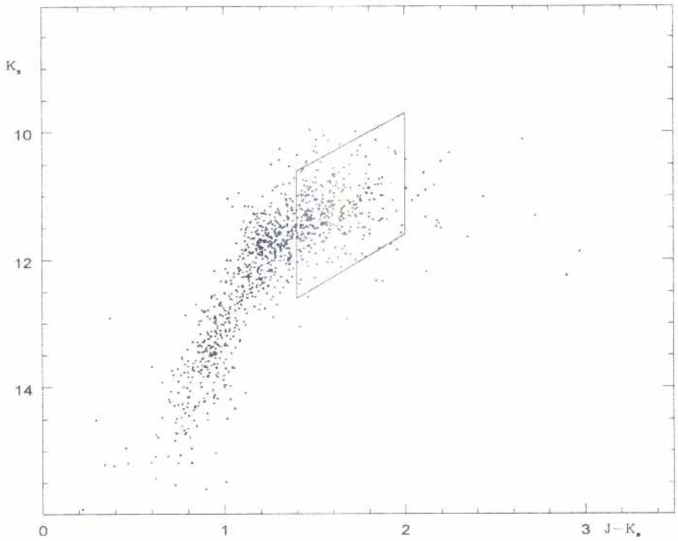

Figure 2: Spectroscopically identified C stars in the SMC. The enclosed area is the J region defined by Nikolaev & Weinberg (2000).

In this regard, the Kacharov et al. (2012) paper is of particular importance. They obtained VIMOS low-resolution spectra of some 800 bright red stars in NGC 6822 in order to spectroscopically calibrate the C and M star selection made using on near-IR photometric data. By combining the spectral classification of these stars with the near-IR photometric data recently published by (Sibbons et al. 2011) based on the UKIRT photometry, Kacharov et al. (2012) were able to compare several C and M identification techniques, both in the CMD and in the two-color planes. They proposed two slightly different methods based on the JHK CMD.

Hereafter, we will focus only on their first method since they lead to essentially similar results. As noted by Kacharov et al. (2012) both methods cannot be used to obtain the absolute number of C and M stars in a galaxy because there is an overlap in the photometric properties of the two types thus a region of the diagram must to excluded. This method can be summarized as follow: M stars are those with $16.45 < K_0 < K_{0,TRGB}$ and $0.9 < (J-K)_0 < 1.2$ while C stars are brighter than the TRGB and have $(J-K)_0 > 1.2$. A detailed description of these thresholds is given in Kacharov et al (2012).

The catalogue of spectroscopically identified AGB C and M stars in NGC 6822 published by Kacharov et al., offers us an excellent opportunity to "verify" the narrow-band selection technique and to better understand its intrinsic difference with the near-IR one. The latter aspect is not at all trivial when one intends to determine the C/M ratios and use them as proxy for the environment metallicity. As it was clearly shown by Battinelli & Demers (2011), C/M ratios determined with the two methods can significantly differ and therefore C/M vs [Fe/H] relations must be separately obtained for both narrow-band and near-IR datasets. While a reasonably good relation has been obtained by Battinelli and Demers (2005) using narrow-band data, a similar relation based on near-IR counts is still missing. Battinelli & Demers (2011, see their Figure 5) found, for a sample of 13 galaxies, a very weak – if any – dependence of C/M near-IR ratios on the metallicity. They therefore concluded that it is an obvious mistake (too often present in the literature) to estimate the metallicity using near-IR counts and C/M vs [Fe/H] relation calibrated by narrow-band counts .

NGC 6822 is an excellent galaxy to inspect these issues because of the great wealth of available data: optical broad and narrow-band (Letarte et al. 2002, Battinelli et al. 2006), near-IR (Sibbons et al. 2011) and low-resolution spectroscopy (Kacharov et al. 2012). In the next section we will therefore adopt NGC 6822 as a case study.

2. THE CASE OF NGC 6822

First we cross-identify the sample of spectroscopically classified stars by Kacharov et al. (2012) with optical R,I,CN, TiO from Letarte et al. (2002) and near-IR by Sibbons et al. (2012), respectively. Figure 3 shows clearly that the selection of C and M stars performed according to RICNTiO photometry is quite satisfactory and in agreement with the spectroscopic classification: approximately all of the spectroscopically confirmed C and M stars lie in their respective box in the RICNTiO plane. In Fig. 3 we note, however, a significant pollution, in the M-box, by foreground dwarf stars. Letarte et al. (2002) accounts for this pollution by statistically subtracting

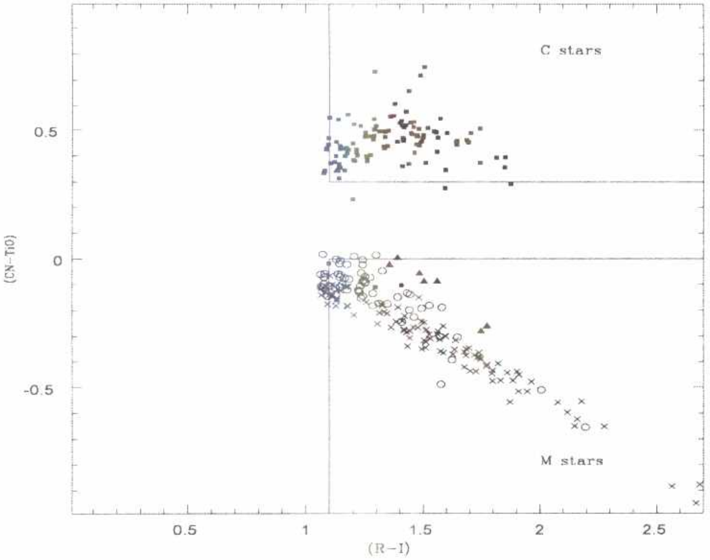

Figure 3: Comparing the narrow-band to the spectroscopic selection criterion. Solid squares: C-rich AGBs; Open circles O-rich AGBs; Crosses: foreground M dwarfs; Solid triangles: S-type AGBs. (R-I) is not corrected for the reddening here.

counts of dwarf M-stars for a foreground control field.

Figure 4 shows a combined narrow-band and near-IR two-color diagram. On one hand, it is evident how the $(J-K)$ color is much more effective in differentiating M giants and foreground dwarfs, on the other hand the $(J-K)_0 = 1.2$ threshold adopted to separate M from C stars in the CMD, cuts out a significant number of the latter. Most of these stars (but not all) are excluded by the bright K-mag cutoff at 16.45 introduced by Kacharov et al. (2012, see their Figure 11).

We should conclude, from Fig. 3 and 4, that a “combined” narrow- (CN-TiO) and broad-band (J-K)colors could - at least for NGC 6822 - be an effective way to determine the C/M ratio. Essentially, once stars brighter than the TRGB are selected, a $(J-K)_0 = 0.90$ is adopted to get rid of foreground M-dwarfs, the usual $(CN-TiO)$ boxes seem to work perfectly.

In the next section we will investigate if such combined approach may yield a reliable C/M vs [Fe/H] relation.

3. A NEW C/M VS [FE/H] RELATION?

As we mentioned in the Introduction, Battinelli & Demers (2005) were able to derive a quite reliable C/M vs [Fe/H] relation using counts from a homogeneous (i.e. obtained using only one C and M identification technique) sample of galaxies.

In this section we try to investigate if it is possible to obtain a similar relation

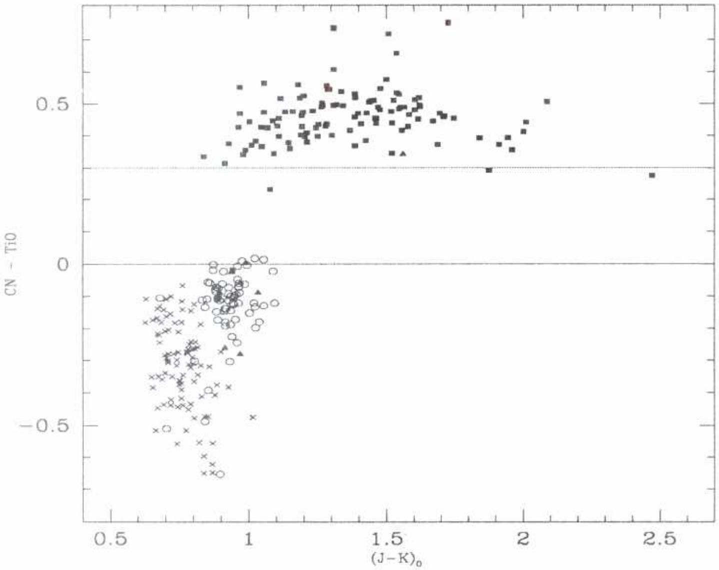

Figure 4: Spectroscopically identified red stars in NGC 6822. Solid squares: C-rich AGBs; Open circles O-rich AGBs; Crosses: foreground M dwarfs; Solid triangles: S-type AGBs.

by using the above described "combined" method. Unfortunately, we found in the literature only four galaxies for which both RICNTiO and near-IR individual photometry can be matched (for some other galaxies coordinates are given only for C stars). These four galaxies are: NGC 6022 (Letarte et al. 2002, Battinelli et al. 2006, Sibbons et al. 2011); IC 1613 (Albert et al. 2000, Battinelli & Demers 2009); IC 10 (Demers et al. 2004; Battinelli et al. 2007) and WLM (Battinelli & Demers 2004; Battinelli et al. 2007). For these galaxies we adopt metallicities from the literature as follow: NGC6822, Battinelli & Demers (2005); IC10, Kim et al. (2009); IC1613, Skillman et al. (2003); WLM, Leaman et al. (2013).

In Table 1, C/M ratios obtained using RICNTiO and "combined" counts are given, alongwith the adopted [Fe/H] for each galaxy.

Even though we are fully aware of the poor statistics of such a sample, we try to determine if a reasonable C/M vs [Fe/H] relation can be obtained. In Figure 5, the C/M vs [Fe/H] relations obtained through the RICNTiO and the "combined" methods are shown. It is evident that the latter method does not at all improve the quality of the relation. More specifically, the correlation coefficients of the two least-square fits shown are $r = 0.73$ and $r = 0.52$ for the left and right panel, respectively.

4. CONCLUSIONS

The combined use of spectroscopic data with available RICNTiO and near-IR pho-

Table 1: Adopted parent galaxy metallicities and C/M ratios obtained using RICNTiO and the "combined" methods.

Name	[Fe/H]	RICNtiO	Combined
NGC 6822	-1.25	1.0	1.27
IC 1613	-1.00	0.64	0.48
IC 10	-1.08	0.23	0.47
WLM	-1.28	12.4	100

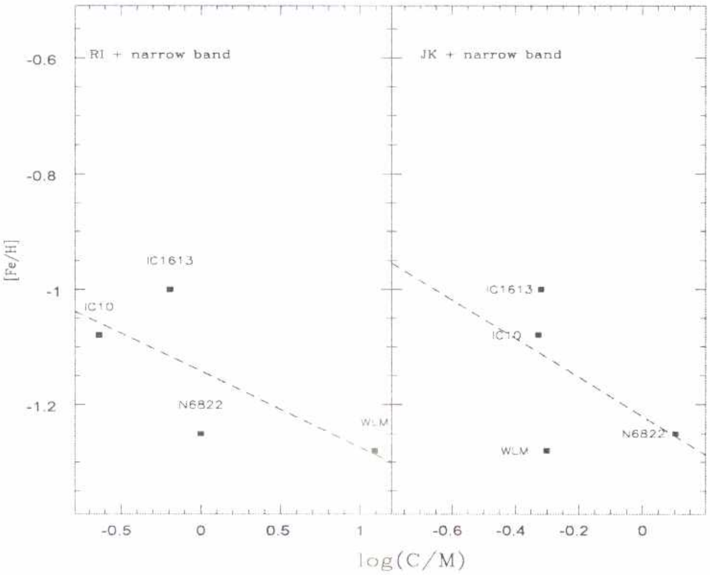

Figure 5: C/M vs [Fe/H] obtained with narrow-band (left panel) and "combined" (right panel) methods.

tometry in NGC 6822, suggests that an effective way to select AGB M and C stars is the combination of $(J-K)$ and $(CN-TiO)$ colors. This approach, in NGC6822, seems to work better that near-IR photometry alone. Indeed, this latter requires the introduction of a (J-K) color threshold (to separate M from C stars) that leads to a loss of a significant number of genuine C stars.

Four galaxies with available RICNTiO and near-IR photometric data are therefore used to investigate if the new "combined" method yields reliable C/M ratios in galaxies with different metallicity. Our result shows that this is not the case and that the C/M vs [Fe/H] relation obtained is worse that the one from RICNTiO.

We believe that this result may be due to the fact that the $(J-K)_0$ thresholds we used for NGC 6822 cannot be applied to galaxies with different metallicities, in other words, these thresholds are function of the parent galaxy metallicity.

It would be very useful if extensive single star spectroscopic data, like the one by Kacharov et al. (2012), would become soon availabe for other galaxies so to shed light on the possible dependance of the $(J-K)_0$ thresholds on the metallicity.

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Publl. Astron. Obs. Belgrade No. 92 (2013), 125 - 126 *Contributed paper*

LONG TERM OPTICAL MONITORING OF AGN

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Abstract. We present our long-term spectral monitoring campaign in the optical band of a sample of broad emission line AGN, using 1m and 6m telescopes of SAO, Russia, and INAOE 2.1m telescope and OAN-SPM 2.1m telescope, Mexico. We have analyzed the broad emission lines properties, with the aim to study the broad line region physics and kinematics. Some of the main results for objects NGC 4151, 3C390.3, and Ark 564, will be outlined.

Presentation link: `http://belissima.aob.rs/Conf2012/Ilic_2012.pdf`

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FIRST SPECTROSCOPICALLY RESOLVED ORBIT OF A SUPERMASSIVE BLACK HOLE BINARY

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Abstract. We present an observational evidence for the first spectroscopically resolved sub-parsec Keplerian orbit of a supermassive black hole binary system in the core of a Seyfert galaxy.

Presentation link: `http://belissima.aob.rs/Conf2012/Bon_2012.pdf`

Publ. Astron. Obs. Belgrade No. 92 (2013), 129 - 130 *Contributed paper*

MODELING OF INTERACTING BINARY SYSTEMS

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Abstract. We present a summary of recent results and publications of the binary star research group within the project Stellar Physics at the Astronomical Observatory of Belgrade. Our study is mainly focused on close, interacting binary stars in various stages of mass transfer, from systems in deep overcontact configurations, to systems with accretion disks. The primary method of our research is modeling of interesting systems based on photometric and spectroscopic observations. Typically, this results in determination of physical parameters of the components and new insights on the nature of the complex interactions between them. The binary system model that we use for this purpose is currently being upgraded in order to accommodate high-precision satellite observations of planetary transits and stellar pulsations.

Presentation link: `http://belissima.aob.rs/Conf2012/Latkovic_2012.pptx`

Publ. Astron. Obs. Belgrade No. 92 (2013), 131 - 136 *Contributed paper*

THE DWARF PROJECT: VIDOJEVICA

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Abstract. The DWARF project is an important international project for observing eclipsing binary stars and searching for third companion which orbit around both stars. Recently, a group of researchers at the Astronomical Observatory of Belgrade joined this project using the 60 cm telescope at the Astronomical Station Vidojevica for observations. All the equipment and the human potential involved with this project from Serbia will be described in this paper.

1. INTRODUCTION

DWARF is an international project aimed at detection of circumbinary extrasolar planets using the timing of the minima of low-mass eclipsing binaries. There are 37 institutes/observatories from 18 countries involved in this project. It was initiated on the IAU conference in 2011, in Slovakia, and realized by Dr. Theodor Pribulla and his colleagues from the Slovakia Observatory. More details about the project can be found in Pribulla et al. (2012) and see also Pribulla in these proceedings.

There are several methods to detect circumbinary planets: (1) precise radial-velocity measurements, (2) photometric detection of transits of the planet across the disks of the components of the inner binary, and (3) timing of the inner binary eclipses. The timing technique proved to be the most effective in detecting circumbinary planets and it will be the principal technique used in the DWARF project (see Lee et al. 2009 for more details on this technique).

Relatively bright binary stars are chosen for observation (R band magnitude between 10 and 17) in order to be observable by small and middle class telescopes, that is, with telescopes ranging from 20 to 200 centimeters in diameter. The program stars in this project can be sorted into three groups: (1) systems with K or/and M dwarf components, (2) systems with hot sub-dwarf (sdO or sdB) and K or M dwarf components and, (3) post-common envelope systems with a white dwarf component.

A group of researchers, working on the project "Stellar Physics" at the Astronomical Observatory of Belgrade, joined this project in 2012. We use the 60 cm telescope located at the Astronomical Station Vidojevica for observations. The observatory and the instruments used for observation will be described in more detail in the first section. The preliminary observing results will be shown in the second section. Some final remarks and the conclusion will be given in the last section.

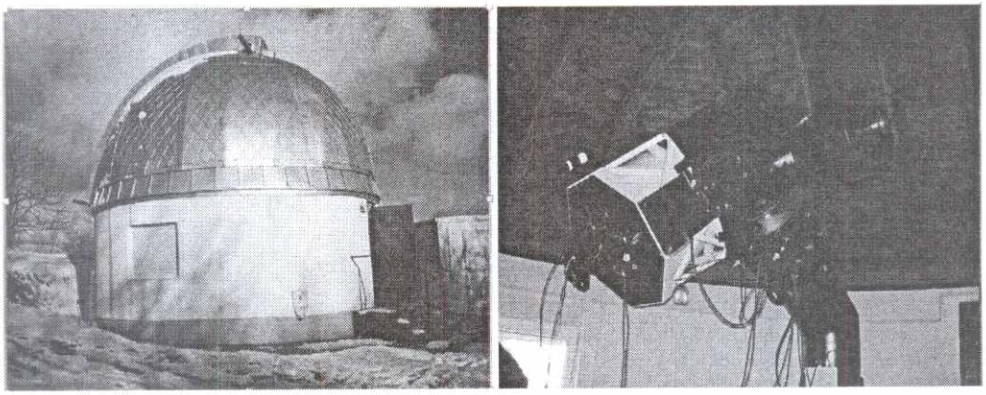

Figure 1: The telescope-dome and the 60 cm telescope at the Astronomical Station Vidojevica

2. OBSERVATORY AND INSTRUMENTS

Astronomical Station Vidojevica is the observational site of the Astronomical Observatory of Belgrade. It is located on the mountain Vidojevica in South Serbia near town Prokuplje. It was founded in 2003 but the first observations were made only in June 2010. Since than, the site was tested for different astro-climate conditions showing that the site has a relatively good seeing (1.2 arcsec in median) and around 100 cloudless nights per year on average (Jovanović et al. 2012).

So far, we have set up only one telescope on the ASV. It is an equatorial mount, Cassagrein system pursued from Astro System Austria company [1]. Mirrors are made in LOMO with 60 cm and 20 cm in diameter for the primary and secondary ones respectively. The telescope was calibrated and tested for different basic characteristics (Vince & Jurković 2011). Figure 1. shows the telescope's pavilion and the 60 cm telescope. We plan to build a new, 1.5 m-class, telescope in a very close future.

For observational purposes, the Astronomical Observatory of Belgrade provided several instruments: portable spectrograph, several CCD cameras, two filter sets (BESSEL and Strömgren) and other auxiliary equipment for different observational projects. The Alta Apogee U42 CCD camera is the most used camera for both, photometry and astrometry. It is a back-illuminated high sensitive CCD with 2048 x 2048 resolution and 13 micron pixel size. It is thoroughly tested for different parameters in Vince (2012). This camera is used for the observation in this project.

The telescope is controlled by the "Autoslew" software. It works under 32-bit Windows system and it is fully compatible with the ASCOM platform enabling communication with other ASCOM-compatible drivers and softwares. The CCD camera and the filter-wheel are controlled by the MaxIm DL imaging software. Recently, the telescope's dome was automatized and synchronized with the slewing of the telescope. At this stage the telescope is ready for the automatization which was the general idea for this telescope.

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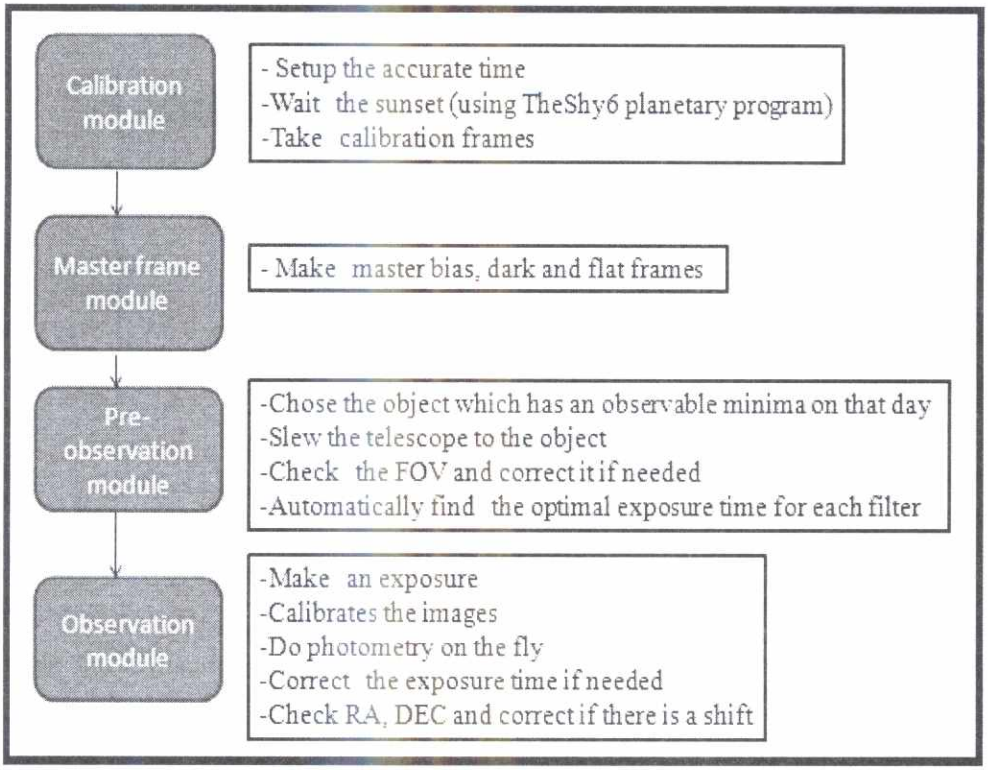
[1] See `http://www.astrosysteme.at`



- Setup the accurate time
-Wait the sunset (using TheShy6 planetary program)
-Take calibration frames

- Make master bias, dark and flat frames

-Chose the object which has an observable minima on that day
-Slew the telescope to the object
-Check the FOV and correct it if needed
-Automatically find the optimal exposure time for each filter

-Make an exposure
-Calibrates the images
-Do photometry on the fly
-Correct the exposure time if needed
-Check RA, DEC and correct if there is a shift

Figure 2: Schema showing the automatization procedure for the observation on the 60cm telescope

3. OBSERVATION AND PRELIMINARY RESULTS

The observation for the DWARF project is fully automatized in Visual Basic Scripting language (VBS). The algorithm for the automatization is schematically shown in Figure 2. Basically, the whole procedure consists of four linear modules as it is shown on the left side and shortly described on the right side of the figure.

In the first module, the calibration images are taken automatically. These are: a) 5 flat-fields in all four BESSEL filters in use (B, V, R, I) with 5 second exposure time which is short enough to take sufficiently large number of flats with high signal to noise ratio and long enough to avoid shutter effect, b) 10 dark flats, that is darks with 5 seconds exposure time for direct correction of the flat frames for the zero level and the thermal noise, c) 10 biases, d) 10 long dark frames for scalable dark correction for the later use.

In the second module, master images are made by combination (averaging or medianing) of the corresponding calibration images. Hot pixel mask is directly obtained from the long exposure dark frames where these pixels rich very high values relative to the average value from the whole frame.

The 'brain' of the algorithm is the third module where the binary system is chosen for observation. This step depends on the ability to observe a particular binary system

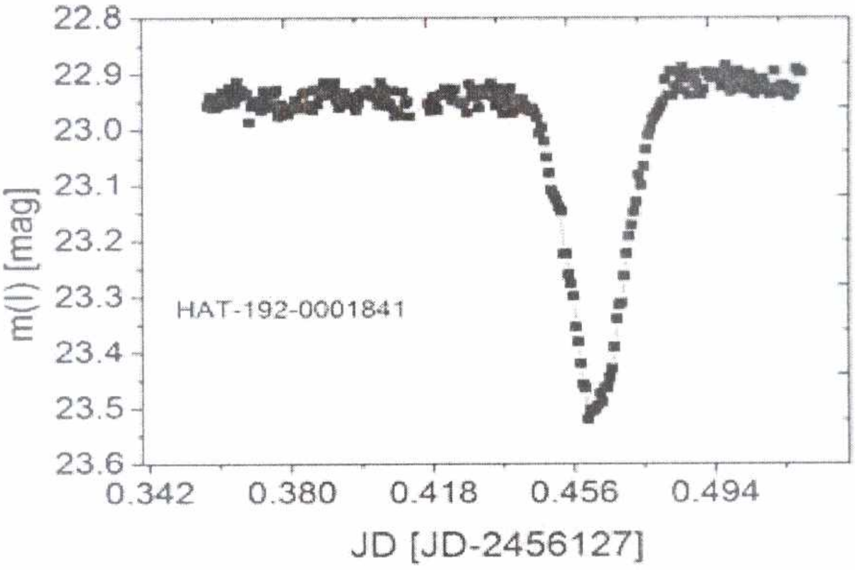


Figure 3: The light-curve of the HAT-192 binary system as an example of the direct output of the VBS script

on that day such as: duration of the period, the relative position of the Moon, the time remained to the sunrise etc.

In the fourth module, the photometry of the binary system is measured on the fly, that is, images are taken and corrected for bias, dark and flat which is followed by the aperture photometry. To ensure that the photometry is measured in the same aperture, the position of the telescope is constantly checked and corrected if the tracking error is larger then the aperture's half-width maximum.

Figure 3. shows an example of the output given by the script. It is the eclipsing binary system HAT-192-0001841 consisting of K and M dwarfs. It is relatively bright object (V band magnitude in the maximum is 14) with short period of 0.31 day. Since we deal with dwarf system, it is observed in the I photometric band. The photometric uncertainty is around 0.02 magnitude.

Although the observation is automatized in a such a way to measure the photometry on the fly, the final results are measured in IRAF data reduction package. This is required by the DWARF project due to unification and homogenization of the observations. However, this step is also accelerated and simplified by writing IRAF scripts which call different IRAF tasks for the aperture photometry[2]. Where the field is crowded with stars, the PSF photometry is performed[3]. To date, we have observed and analyzed three binary systems: HAT-192-0001841, HS 2231+2441, and NSVS 14256825.

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[2] See `http://iraf.noao.edu/iraf/docs/apuser.ps.Z`

[3] See `http://iraf.noao.edu/iraf/docs/daorefman.ps.Z`

4. FINAL REMARKS

According to our experience so far, there are several things that deserve attention in order to perform high-quality observations for this project:

i.) The shutter delay, that is, the delay that occurs between the instant of issuing the command to start an exposure and the instant at which the shutter actually opens. Of course, it is important to take this effect into account since we are measuring the variation of the light-curve minima of the binary systems. Fortunately, this effect is very close to zero for this camera but can be much larger for some cameras (like in the example of our Alta Apogee E47 CCD camera where this delay is 0.43. seconds). It would be important for all members of the DWARF project to correct observations for this effect.

ii.) The shutter effect, that is, the uneven exposure of the detector to the light due to the finite time needed to open and close the shutter. Our CCD camera has an IRIS shutter (blades are opened from center to the edge) which means that the central region of the detector is the most exposed to the light. Short exposures are frequently used for making flat images and they very often suffer from this effect. Calibration of images for flat-field with this flats can be quite catastrophic in some cases.

iii.) Non-linearity of the CCD camera. This parameter is the most important to know for accurate photometry.

iv.) The fringing, that is, the pattern very often present in the I band (even in R band in some cases). It is caused by interference of the light in the thin emulsion layer of the CCD detector. There are useful information on the Internet how to make correction for this effect.

To conclude, having these remarks on mind, we can perform quite accurate photometry with the 60 cm telescope at the ASV and positively contribute to the DWARF project. Since 1980's, when the observations in Belgrade were terminated due to light pollution, Serbia is for the first time active again in observational projects. These activities will be certainly improved with the new 1.5 m-class telescope that is being purchased.

ACKNOWLEDGEMENTS. The author thanks projects "Visible and invisible matter in nearby galaxies: Theory and observations" (ON176021) and "Stellar Physics" (ON176004) which are supported by the Ministry of Education, Science and Technological Development of the Republic of Serbia.

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Publ. Astron. Obs. Belgrade No. 92 (2013), 137 - 146 *Invited lecture*

MASS-LOSS RATES OF HOT STARS

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Abstract. Methods of hot star mass-loss rates determination based on observations in ultraviolet, visual, infrared, and radio spectral regions are discussed and compared with values theoretically predicted by hydrodynamical calculations. The effect of wind inhomogeneities (clumping) on line formation calculations is discussed.

1. Introduction

In this paper we concentrate on O-type stars (with $T_{\rm eff} \gtrsim 30000\,{\rm K}$). These stars are luminous ($L \gtrsim 10^6\,{\rm L}_\odot$), massive ($M \gtrsim 8\,{\rm M}_\odot$), they live very shortly (about 10^6 years), and they end their lifes as supernova explosions. They are relatively rare, and they form only a small fraction of the stellar population. Hot stars may be seen even at large distances. They heat-up and ionize their surroundings, and enrich the interstellar medium with heavier elements (metals). They also provide kinetic energy to the interstellar medium via stellar winds and at the end of their existence via supernovae explosions. They also trigger, regulate and terminate star formation in stellar clusters (see, e.g., Cesaroni 2005, Bresolin 2008, and references therein).

The stellar wind is an outflow of material from the stellar surface. The rate at which the mass is being lost (the mass-loss rate, $\mathrm{d}M/\mathrm{d}t$) may reach values up to about $10^6\,{\rm M}_\odot\,{\rm year}^{-1}$. The wind terminal velocities can be up to about $3000\,{\rm km\,s}^{-1}$. The outflow from hot stars is accelerated by radiation, which interacts with the wind matter. Although the continuum opacity (electron scattering, bound-free and free-free) can supply a significant amount of momentum from radiation to the wind, it is not sufficient to drive the wind. One has to add the line opacity (dominantly by resonance lines of metals) to obtain radiation force which is able to overcome the gravity. Since the radiation force acting on hydrogen and helium is very small, necessary momentum is transferred from metals to hydrogen and helium by Coulomb collisions (see Krtička & Kubát 2007).

The most important quantity describing the wind is its mass-loss rate. It can be determined using observational data, however in combination with the theoretical background and sophisticated modelling.

2. Wind hydrodynamical models

Hydrodynamical models of the wind are usually calculated using several restricting assumptions. The models are assumed to be stationary, homogeneous, and spherically symmetric. This means that all variables depend only on the radius r. To calculate a hydrodynamical model of the stellar wind, one has to solve the continuity equation (which determines the density structure $\rho(r)$), the equation of motion (which determines the wind velocity $v(r)$), and the energy equation (determining the temperature structure $T(r)$). The radiation field has crucial influence on the wind structure and dynamics. The accelerating force caused by radiation in wind hydrodynamical models can be expressed as

$$g_{\rm rad} = \frac{\pi}{c\rho}\int_0^\infty \chi(\nu)F(\nu)\,{\rm d}\nu. \tag{1}$$

To evaluate this force, it is necessary to know the radiation flux $F(\nu)$ and the opacity $\chi(\nu)$ for all frequencies. To simplify the problem, the so-called force multipliers k, α, and δ (Castor, Abbott, & Klein 1975; Abbott 1982) can be used for evaluation of the radiative force. These free parameters have a physical interpretation, namely δ reflects the ionization balance, α corresponds to line distribution, and k describes the line strength.

Although many successful models have been calculated using this CAK approximation, detailed calculations of the radiative force are now available and should be preferred. To calculate opacities in detail, it is necessary to know correct (i.e. NLTE) atomic level populations of dominant absorbing ions causing the wind acceleration. Detailed calculations of the radiative force using NLTE occupation numbers have been done using the Monte Carlo method (Vink et al., 1999) or using detailed treatment of the equations of statistical equilibrium (Krtička & Kubát 2004), who included this evaluation of the radiative force into the construction of hydrodynamical wind models. In the latter method, the global stellar parameters are used as an input to the wind hydrodynamical models, namely the stellar radius (R_*), the stellar mass (M_*), the stellar luminosity (L_*), and the chemical composition of the star. Additional necessary input is the radiation flux $F(\nu)$ at the lower wind boundary, which is usually taken from some static photosphere model or it is simply assumed to have a blackbody distribution. The latter option is, however, not too exact.

After solving the hydrodynamic equations we obtain the hydrodynamic wind model. The output from the calculations is the velocity structure $v(r)$, density structure $\rho(r)$, and temperature structure $T(r)$. This solution also gives basic global wind parameters. From the velocity profile we may determine the terminal wind velocity v_∞, which can then be measured from P-Cygni type profiles, and in combination with the density structure we can determine the mass-loss rate ${\rm d}M/{\rm d}t = \dot{M}$.

The radiative transfer in lines is solved using the Sobolev approximation in this method, while the continuum radiative transfer may be treated as in the static case. The method has been recently upgraded and the region close to the star is treated without assuming the Sobolev approximation, instead the so-called comoving frame method is used (see Krtička & Kubát 2010).

3. Mass-loss rate determination

The common way to determine mass-loss rates from observations is to use the fit of selected observed spectral features with the model prediction. The process is such that for *given* $v(r)$ and $\rho(r)$ (consequently $\mathrm{d}M/\mathrm{d}t$ and v_∞) we determine the emergent radiation, which is then compared with observations. Results of hydrodynamical model calculations are the most suitable models for this task. However, the density and velocity structures are often determined using very simplified wind models. Usually, the velocity law $v(r)$ is not taken as a result of hydrodynamic calculations. Commonly a simplifying assumption of the so-called β-velocity law,

$$v = v_\infty \left(1 - \frac{R_*}{r}\right)^\beta , \tag{2}$$

is used. The velocity law of this form was first formulated by Milne (1926) and Chandrasekhar (1934) with $\beta = 0.5$.

Several different spectral regions are being used for mass-loss rate determination. Each of them has its strenghts, but also weaknesses.

Radio measurements Using radio emission is considered as the most reliable method for mass-loss rate measurements. It is based on detection of radiation coming from the outermost parts of the wind, where the wind velocity is nearly v_∞, i.e. it is almost constant. The outer wind is assumed to be spherically symmetric, fully ionized, and in local thermodynamic equilibrium. The dominant source of radiation at radio wavelengths in this region is the free-free emission, which is of a thermal origin. Consequently, the assumption of the local thermodynamic equilibrium is valid for this process. These assumptions allow to derive a simple expression of a mass-loss rate depending on the terminal wind velocity, measured radio flux, and the stellar distance (see Panagia & Felli 1975; Wright & Barlow 1975). Since the distance of the stars has to be known, this type of mass-loss rate determination is restricted to closest stars. Unfortunately, the radio radiation from hot stars is usually very weak, so we are restricted only to the brightest objects. In addition, the method gives reliable results if the radio radiation is thermal. The possible influence of non-thermal radio radiation may complicate situation.

Hα line profiles Contrary to radio radiation, the Hα emission originates in inner regions of the wind. In this method, observed profiles of the hydrogen Hα line are compared with the theoretical ones. Then the mass-loss rate corresponding to the model with the best fit is called the *observed mass loss rate*.

The calculations are often based on sophisticated NLTE wind models, which determine actual level populations and emergent radiation for a given density and velocity structure. The velocity dependence is usually described using the simple β-velocity law (2) and the core-halo approximation is assumed. This approximation artificially separates the photosphere and the wind, the photospheric radiation enters the wind, but there is no influence from the wind on the photosphere. There exist several computer codes, which are able to solve the problem of line formation in the wind, namely the CMFGEN code (Hillier & Miller 1998), the WMBasic code (e.g. Pauldrach et al., 2003, and references therein), the FASTWIND code (Santolaya-Rey et al. 1997, Puls et al. 2005), and the PoWR code (e.g. Hamann & Gräfener 2004).

UV (resonance) line profiles Ultraviolet resonance lines may serve as a tool for determination of $\dot{M}q_i$, where q_i is the ionization fraction of the corresponding ion. If the ion is the dominant one (i.e. if the fraction is 1 or close to it), then the resonance lines give directly the mass-loss rate. However, the strongest ultraviolet resonance lines are often saturated. This happens, for example, for the case of C IV (1548, 1551 Å) or N V (1239, 1243 Å). In this case, these lines are almost insensitive to changes of $\dot{M}$, consequently they indicate only the lower limit of $\dot{M}$. On the other hand, the lines of less abundant elements are unsaturated, like it happens for the case of Si IV (1394, 1403 Å) or P V (1118, 1128 Å) resonance doublets. These lines are, consequently, more sensitive to changes of $\dot{M}q_i$, and may be used as useful mass-loss rates indicators. The importance of the P V resonance doublet 1118, 1128 Å was pointed out by Crowther et al. (2002). Careful analysis of a number of stars by Fullerton et al. (2006) resulted in disagreement between the derived mass-loss rates from the P V line and using other methods. It lead to a conclusion that either the P V mass-loss rates are wrong or the ionization fraction of P V is lower than 0.1. Subsequent NLTE calculations of Krtička & Kubát (2009, 2012) showed that the lower ionization fraction does not seem to be the solution to the disagreement, since neither additional X-ray nor XUV radiation are able to lower the ionization fraction of P V.

Comparison of measurement methods Different methods of mass-loss rate determination depend differently on the density. While the strength of the ultraviolet resonance lines depends linearly on the density, radio determinations are dependent on the square root of density (due to the collision nature of the free-free process). Since the Hα emission line is assumed to be formed predominantly by cascading of the atoms recombined to higher levels, the Hα diagnostics is also classified as density-squared dependent. All mass-loss rate determination methods should give the same result. However, different mass-loss diagnostics result in different mass-loss rates (e.g. Puls et al., 2008).

Comparison between observations and theory In addition to differences between mass-loss rates determined from different diagnostics tools, for some stars there is a significant difference between theoretical mass-loss rates (from hydrodynamical calculations) and those derived from observations. These stars are especially the cool O-type dwarfs, whose winds should be weaker than of hotter O-type stars, but they are even more weak than the mass-loss rates predicted from models. This is called the *"weak wind problem"*. This was demostrated by Bouret et al. (2003) and Martins et al. (2004) for the case of several SMC O-type dwarfs, and by Martins et al. (2004) and Marcolino et al. (2009) for Galactic O-type dwarfs. The short history of the weak-wind problem was summarized by Puls et al. (2009). Selected weak wind stars are listed in the Table 1.

It is not clear what is the exact reason for the existence of the weak wind problem. Several processes were discussed by Martins et al. (2005) and summarized by Puls et al. (2009). However, our recent results (in progress) show that the most probable

Table 1: Mass loss rates for selected "weak wind stars". Observational mass-loss rates are from: B – Bouret et al. (2003), M – Martins et al. (2005), W – Marcolino et al. (2009). Errors of observational determinations are not listed. The column "pred." lists values of predicted mass-loss rates from the observational references, which were calculated after Vink et al. (2000, 2001). The column shows the mass-loss rates from hydrodynamical calculations using the NLTE wind code by Krtička & Kubát (2004): K – Krtička (2006), X – Krtička & Kubát (2009).

star	$T_{\rm eff}$ [kK]	$\log g$ [g·cm^{-2}]	$\dot M$ [M$_\odot$ year^{-1}]				
			observations		pred.	hydro	
NGC 346 MPG 12	31	3.6	$1.0 \cdot 10^{-10}$	B	$4.0 \cdot 10^{-8}$	$1.7 \cdot 10^{-8}$	K
NGC 346 MPG 487	31	3.6	$3.0 \cdot 10^{-9}$	B	$7.9 \cdot 10^{-8}$	$3.0 \cdot 10^{-8}$	K
HD 326329	31	3.9	$6.0 \cdot 10^{-10}$	W	$4.2 \cdot 10^{-8}$		
HD 149757 (ζ Oph)	32	3.6	$1.6 \cdot 10^{-9}$	W	$1.3 \cdot 10^{-7}$	$4.7 \cdot 10^{-8}$	X
HD 34078 (AE Aur)	33	4.05	$3.2 \cdot 10^{-10}$	M	$4.2 \cdot 10^{-8}$	$1.4 \cdot 10^{-8}$	X
HD 38666 (μ Col)	33	4.0	$3.2 \cdot 10^{-10}$	M	$3.9 \cdot 10^{-8}$	$7.9 \cdot 10^{-9}$	X
HD 46202	33	4.0	$1.3 \cdot 10^{-9}$	M	$5.9 \cdot 10^{-8}$	$2.3 \cdot 10^{-8}$	X
HD 216532	33	3.7	$6.0 \cdot 10^{-10}$	W	$1.2 \cdot 10^{-7}$		
HD 93028	34	4.0	$1.0 \cdot 10^{-9}$	M	$1.3 \cdot 10^{-7}$		
HD 216898	34	4.0	$4.5 \cdot 10^{-10}$	W	$6.0 \cdot 10^{-8}$		
HD 66788	34	4.0	$1.2 \cdot 10^{-9}$	W	$1.1 \cdot 10^{-7}$		
HD 93146	37	4.0	$5.6 \cdot 10^{-8}$	M	$2.6 \cdot 10^{-7}$		
HD 42088	38	4.0	$1.0 \cdot 10^{-8}$	M	$6.8 \cdot 10^{-7}$	$3.1 \cdot 10^{-7}$	X
NGC 346 MPG 113	40	4.0	$3.0 \cdot 10^{-9}$	B	$1.3 \cdot 10^{-7}$	$4.8 \cdot 10^{-8}$	K

physical process, which could be able to correct the disagreement is wind clumping. Consequently, the most promising way to correct the disagreement is to include clumping into both line formation calculations and hydrodynamic wind models.

4. Clumping in stellar winds

It is highly probable that stellar winds are not smooth, but that they form various condensations at different scales. There is indeed some evidence of such clumping. Observations of Eversberg et al. (1998) repeatedly showed differently travelling bumps at a series of difference spectra of the bright O-type star ζ Pup. These spectra were obtained within two single subsequent nights. These travelling structures in the line profiles could be interpreted as a consequence of absorption in random small-scale structures in both density and velocity, which were moving in the wind. The theoretical evidence of clumping follows indirectly from 1-D radiative hydrodynamic simulations (see, e.g., Runacres & Owocki 2002). As a consequence of the radiative-acoustic instability, structures in radial velocity $v(r)$ and density $\rho(r)$ profiles occur. However, full 3-D hydrodynamical simulations are still missing, so we assume that the 1-D structures represent the way how real 3-D structures may develop and look like.

Although it is commonly accepted that the stellar winds are clumped, details of clumping (clump distribution, clump shapes, their density and velocity) are largely unknown. To include clumping in wind modelling, a description of clumps using adjustable parameters is used together with further simplifying assumptions.

In many NLTE wind codes, where the emergent radiation is consistently determined with the atomic level occupation numbers, clumping is treated using single free parameter. *All* wind matter is assumed to be concentrated in clumps (i.e. clumps are in vacuum). Then it is possible to introduce the (volume) filling factor as a ratio of the volume occupied by clumps V_{cl} and the total volume of the wind V_{wind},

$$f = \frac{V_{\mathrm{cl}}}{V_{\mathrm{wind}}}. \tag{3a}$$

Alternatively, clumping may be described using the clumping factor ($\langle\rho_{\mathrm{cl}}\rangle$ is the average density inside clumps and $\langle\rho_{\mathrm{wind}}\rangle$ is the average wind density)

$$D = \frac{\langle\rho_{\mathrm{cl}}\rangle}{\langle\rho_{\mathrm{wind}}\rangle} = \frac{1}{f}, \tag{3b}$$

which is the inverse of the volume filling factor[1]. In addition, *all* clumps are assumed to be optically thin. This approach is usually referred to as the *microclumping*. The assumption of optically thin clumps allows to express the opacity in the wind as

$$\chi = \frac{1}{D}\chi_{\mathrm{cl}} \tag{4}$$

where χ_{cl} is the opacity of the material in clumps. Since $\rho_{\mathrm{cl}} = D\rho_{\mathrm{wind}}$ (note that $D > 1$, since $\rho_{\mathrm{cl}} = D\rho_{\mathrm{wind}}$), the actual effect of clumping depends on the physical process. For processes with opacities proportional to the density ($\chi \sim \rho$), like, e.g.,

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[1] Alternatively, the clumping factor is sometimes denoted as C_c or f_{cl}.

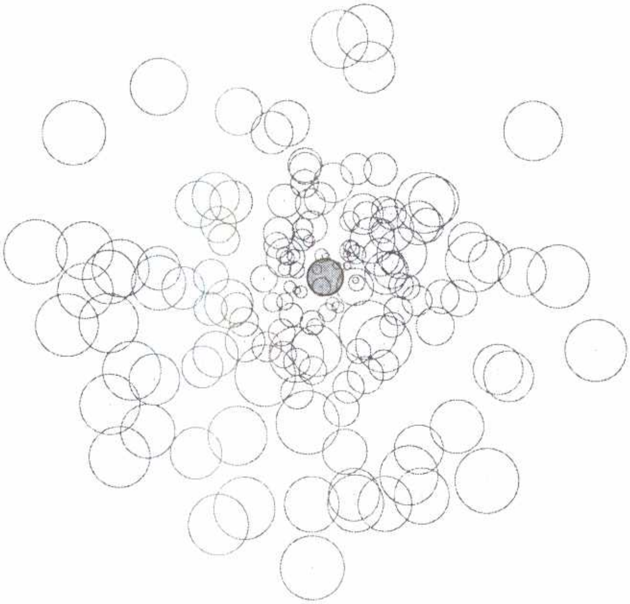

Figure 1: An example of wind clumping represented by randomly distributed spherical clumps. The picture was generated by a code developed by Šurlan (2012).

resonance line scattering, the opacity in the clumped wind is the same as in the smooth wind. For processes with opacities depending on the second power of density ($\chi \sim \rho^2$), like recombination or free-free transitions, the opacity is higher.

However, in reality we can not assume that all clumps are optically thin. Consequently, the influence of clumping can not be expressed as simply as in Equation (4). We have to take into account the fact that some clumps may be optically thick. This approach is referred to as the *macroclumping* (or porosity). Since the clumps may be optically thick in this approach, it may happen that they shield each other and, as a result, some matter is effectively excluded from the radiation-matter interaction. At the same time, more matter concentrated in clumps causes larger interclump medium (which is usually considered as void) and higher probablity that the photon does not interact with matter. The opacity dependence on the degree of clumping is more complicated and has to be taken into account in detail using multidimensional radiative transfer.

Modelling of wind clumping A method of handling macroclumping using a 3-D Monte Carlo radiative transfer code is described in Šurlan et al. (2012a). In this method several above mentioned assumptions are released. First, the optical thickness of clumps is calculated consistently based on the local clump density and its optical properties. Consequently, clumps may be optically thick, which allows to handle the above mentioned case of macroclumping. The interclump medium is allowed to be non-void, which is closer to reality. Clumps are assumed to have a spherical shape and they are distributed using the probability distribution derived from the velocity law. In the above mentioned paper pure resonance line scattering is taken into account. The transfer of radiation is solved using the Monte Carlo method. More details about this method may be found in Šurlan (2012) and Šurlan et al. (2012a).

Effect of the macroclumping on resonance line profiles Our results showed strong influence of the clumping factor on resulting line profiles. The profiles are shallower with higher clumping factor showing the effects of effective lowering opacity for optically thick clumps. Also velocity clumping (vorosity), non-void inter-clump medium, location of the onset of clumping influence the line profiles. All these effects influence the mass-loss rate determination based on such lines, as it was shown by Šurlan et al. (2012b).

5. Summary

Despite sophisticated theory of hot star winds, mass-loss rates are still not firmly determined. Multiwavelength observations are necessary for mass-loss rate determination. Line profiles in clumped wind strongly depend on clump properties. Observational study of clumping in bright stars winds is a suitable program for small class telescopes.

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Posters

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POPULARIZATION OF ASTRONOMY THROUGH ROBOTIC TELESCOPES AND VIRTUAL OBSERVATORIES

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Abstract. Robotic telescopes and virtual observatories have great impact on popularization of astronomy. In this paper we will present several web services and observatories that allow remote control over their equipment, which have great contribution in astronomy promotion. In addition, the first Serbian amateur robotic observatory will be presented (Night Hawk, Bačka Palanka). Finally, an economic review of this concept is done to consider its attainability to the general audience.

1. OVERVIEW

Robotic Observatory (telescope) is defined as an astronomical instrument and detection system which allows the observation without the need for physical intervention of operator. In astronomy, a telescope is considered robotic when observations can be performed without operator intervention on the equipment (even if one has to start and complete a monitoring session on it). Robotic telescopes are complex systems consisting of several subsystems. These subsystems include devices that allow: 1) control of the telescope, 2) control of the detector (usually CCD camera), 3) control of the dome (roof) of observatory, 4) control the telescopes focuser, 5) tracking of celestial objects within a few arc seconds to a few arc minutes, 6) avoiding wrapping the cord around the mount, 7) obtaining special points in the sky, 8) knowledge of the horizontal border movement of the telescope limits, 9) initial "parking" position of telescope, 10) exposure control and control of camera temperature, 11) filter control, 12) storing images and their subsequent processing using the dark frame and flat field, 13) synchronizing movement of the telescope with the sky and so on. Most robotic telescopes are small telescopes. The emergence of the Internet has enabled robotic telescopes to become accessible to a large number of users worldwide. The Internet helps to reduce costs in communicating with users. It also offers the possibility of a wider range of potential users to get to know how to control the telescope. Thanks to the Internet, robotic telescopes are becoming an important element in teaching of astronomy. The Internet also provides an opportunity for communication, data exchange and verification of observational data obtained by many research teams worldwide. It can be concluded that the Internet in the concept of "Astronomy from the chair" is becoming an important tool for dealing with astronomy.

A virtual observatory (VO) is defined as a set of databases and software that use the Internet as a platform for astronomical research. A virtual observatory operates in a similar way like a real one, which consists of telescopes. The goal is to provide transparent access to data to users worldwide. In this way, scientists can discover, analyse and combine natural phenomena and laboratory data collected in databases. There are website groups that allow amateur astronomers to take advantage of VOs to participate in scientific research. One such example is Zooniverse.

2. VIRTUAL TELESCOPE (www.virtualtelescope.eu)

Virtual Telescope (VT) project started at 2006. It was one of the first projects related to public observations and conferences using modern information and communication technologies. The goal of this project is to provide access of professional astronomical equipment to general audience, which can use it to observe and manipulate data from their home. The equipment is used for research and for amateur astronomy. The system is configured to produce best results on photometry, but can also be used for other purposes. In addition, people without any astronomical experience can use the equipment with the help of technical staff, who are also good science communicators. VT project uses the equipment of Bellatrix observatory which is built in 1997. at Ceccano, central Italy. The observatory has two telescopes (Celestron 14" and PlaneWave 17") and CCD cameras with other components. With this equipment, deep sky objects, binary stars, star clusters, Sun, Moon, planets, asteroids and comets can be observed. The observatory is completely computerized, equipped with 3 computers for image management and editing. The software used are CCD soft, The Sky, Iris, IDL and Astrometrica. Since 2013 it is updated with TheSkyX. The area of the observatory is 14 m^2 and it has removable roof. The founder of this project is Italian astrophysicist Gianluca Masi, who is leader of the project, and the assistant is Gisella Luccone. VT project organizes the following activities: telescope control, public observations and exclusive public observations. During 6 years, 1300000 people from more than 200 countries attended activities within this project. The use of social networks greatly contributed to the success. The Facebook page of the project has more than 4300 members, and besides it, there are 2 more groups with 4900 and 890 members respectively (september 2012).

3. ZOONIVERSE (www.zooniverse.org)

Zooniverse is the largest and the most successful project intended for citizen science. Zooniverse projects are developed and maintained by Citizen Science Alliance. The project started at 2007. with the project GalaxyZoo-Hubble. Beside this one, there are 9 more projects available today: Ancient Lives, Old Weather, Ice hunters, Planet hunters, The Milky Way Project, Moon Zoo, Galaxy Zoo (understanding cosmic mergers), Galaxy Zoo (the hunt for supernovae) and Solar Starmwatch.

For each of projects listed above, a short training in the form of text or animation is available, to allow users successful start of research. They can get detailed information about the particular topic. The motif of this project is to include human factor

Figure 1: VT website

to overcome problems that technology and supercomputers are not able to perform appropriately. For example, detection of extrasolar planets orbiting around distant stars is difficult to perform. Humans are able to recognize these events as well as some unwanted phenomena in order to remove them. We will describe Planet Hunters and Galaxy Zoo - Hubble projects.

3. 1. PLANET HUNTERS (WWW.PLANETHUNTERS.ORG)

Planet Hunters is the latest projects developed within Zooniverse. Participants can get data from Kepler mission (stellar luminosities), create light curves, and analyse them. Based on light curve analysis, users should find traces of possible planet transits. If significant number of such events are reported for the same object, scientists continue to further explore it. So far, more than 4900000 cases have been studied and 34 of them are marked as candidates for extrasolar planet systems.

3. 2. GALAXY ZOO - HUBBLE (WWW.GALAXYZOO.ORG)

Galaxy Zoo - Hubble is the first project under Zooniverse project. Before starting the work, users can take opportunity to inform themselves about the project and the way how they can participate. By answering questions, they help researchers to classify galaxies. First version of this project had 2 tasks: to separate galaxies in spiral and non-spiral, and if they are spiral, to determine the direction of arms. New version has more questions (18), but the number of questions that user actually gets depends on previous answers. During 14 months, since the first version started, more than 60000000 galaxies were classified.

4. NIGHT HAWK (univerzumad.com)

Night Hawk is the first amateur observatory in Serbia which is computerised and robotised. The communication exists in both directions through the Internet. Users can remotely drive the telescope and the images are delivered from the observatory to users. In this way, users have full control as if they were on the spot in the observatory building.

The observatory is open on April 16, 2011. and is located in Bačka Palanka and belongs to AS Univerzum. It is built by Janko Mravik, amateur astronomer, president of AS Univerzum. It is 6m^2, 5m wide with the telescope room and working room. The building is covered by the removable and remote controllable roof. The observatory has the following equipment: Telescope (GSO 250/1250 on EQ6 sky scan mount); Main camera (CCD Astropix 1.4, mounted on the telescope); Inner camera (used for monitoring interior (room and the telescope itself)); Outer camera (used for monitoring exterior and the building); Wide-field camera (60° ×40° of the sky, useful for meteor observations); Meteorological station (monitor weather conditions, in the case of rain, the roof is closed automatically to protect interior); 3 computers (networked and connected to the Internet, used for observations and controlling the observatory).

During 1 year, the observatory discovered 1 variable star and recorded transits of 30 extrasolar planets. All events are confirmed by competent registries. Although it is physically located in Bačka Palanka, the fact that it contains robotised telescope and remote control via the Internet allows the observatory to be used by anyone regardless of geographical location and without need for physical presence.

5. ECONOMIC ANALYSIS

Economic analysis is based on equipment similar to Night Hawk observatory, because it can be easily found on Serbian astronomical equipment market. The goal is to determine the payback period of investment in such observatory. The assumption is that the owner already has the building which does not need further investments. Since the average salary in Serbia is about 350 €, it means that this solution is not accessible for the majority of people. If we consider that equipment for astrophotography costs 3625 € and one observational hour costs 10 €, then for 3625 € a person can book and use a total of 363 telescope hours for his observing sessions. This is especially useful for people who rarely have the opportunity to engage in astrophotography and want above all to observe night sky, which can be done without any financial compensation by attending online public observing sessions which are free (example Virtual Telescope), or using a Astronomylive site (www.astronomylive.com). If we suppose that the owner rents the telescope for 10 €/h, then payback period is given in Table 1.

Table 1: Economic analysis

hours leased per month	total hours leased in 1 year	payback period
30	360	< 2 years
15	130	3 years
10	120	4 years
5	60	7 years

This calculation does not include observatory construction, equipment maintenance, taxes and other expenses, so including them will extend the payback period. Nevertheless, schools do have interest to purchase time in these observatories because this concept provides astronomical observations to the general audience, for an affordable price.

Publl. Astron. Obs. Belgrade No. 92 (2013), 153 - 156 *Poster*

MONECOM: PHYSICAL CHARACTERISTICS OF MAIN BELT COMETS

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Abstract. The aim of the MONECOM project is to carry out photometric observations of several Main-Belt Comets (MBCs). Observations and data reduction were performed by high-school students from three countries (Croatia, Greece and Serbia), supervised by their teachers and local astronomers. Here we present some results obtained by the Serbian group.

1. INTRODUCTION

In order to get high school students interested in science, particularly in astronomy (which is not part of standard high school curriculum in Serbia, see paper by Atanacković, these proceedings), it is of great importance to give them opportunity to use modern equipment, as well as to introduce them to modern trends and recent discoveries. The MONECOM project tries to address both issues. The idea of the project it to gather three groups of high school students, one from Croatia, one from Greece and one from Serbia, and to apply for the observing time on the remote MONET telescopes in order to observe main belt comets (MBCs). The MONET telescopes are superior to any of the local telescopes available to those students. Also, main belt comets are a relatively recent discovery in solar system astronomy. Only a handful of them are discovered so far and they seem to attract significant attention of researchers interested in small bodies of the Solar system.

The main educational goal of the project is to get the students through whole process of observations, data reduction and, if possible, data interpretation. However, we wanted the project to have a scientific aspect as well: via multi-band photometry we hoped to detect some signs of activity in the observed MBCs.

Preparation and initial training of the students were carried out by their teachers/tutors, and supervised by a local professional astronomer. In this paper we report on the activities done by group of students from Serbia. The group consisted of eight students, age 15 to 19. They all come from different high schools but attend astronomy seminars in Petnica Science Center (PSC; for details see contribution by Milić et al. in these proceedings). The group was coordinated by Igor Smolić and Ivan Milić, senior assistants and former department heads at PSC. The whole project was supervised and supported by Milan Bogosavljević, member of the staff of the Astronomical Observatory of Belgrade. Additional support and assistance were provided by four more junior assistants (undergraduate/master students) from the department of Astronomy department of PSC.

2. OBSERVATIONS

The initial plan was to apply for two nights for each of the groups. Our group covered nights of $28/29^{th}$ and $30/31^{st}$ of October. We used MONET North telescope, located at McDonald observatory (Bischoff et al., 2006; Hessman, 2007). Telescope was remotely controlled by students and supervisors from the Astronomical station Vidojevica. The additional pedagogical effect was to allow students to get familiar with the 60 cm reflector telescope at Vidojevica and to also perform some test observations using it. The MBCs observations were part of a four-day "mini-seminar" held for Petnica students since at the moment main objects of PSC were closed for renovation.

Prior to observations, instructions on using the MONET interface, taking various kinds of frames and taking necessary precautions were given to all the students. All of them had attended some elementary lectures on telescopes, CCDs and photometry in general on seminars in previous years. The main observational plan consisted of observing three MBCs:

1. 176P/Linear,
2. 238P/Read (P/2005 U1),
3. P/2010 R2 (La Sagra).

3. RESULTS

We gathered data during approximately eight hours of observations, in two intervals. The data were preliminary examined "on the fly", and later processed during the summer school of astronomy in Petnica Science center in 2012. A short image processing workshop was organized with students who were participating in the MONECOM project, and also to other interested students.

The data processing was completely performed by Nina Bogdanović, high school student attending the seminar at the time, using MaximDL, AstroArt and DS9 software packages. Dark current subtraction and flat-field reduction were performed for all the images and images were stacked in order to increase S/N ratio and visually identify the objects. In Figure 1 we show the detection of READ/238P MBC in the R filter. The total of 20 minutes of exposure was stacked in order to obtain the image. We see that the comet can be identified, however, precise photometry was impossible due to the fact that the comet happened to be transiting a star in the field at the moment of observation. We have dedicated approximately the same exposure to

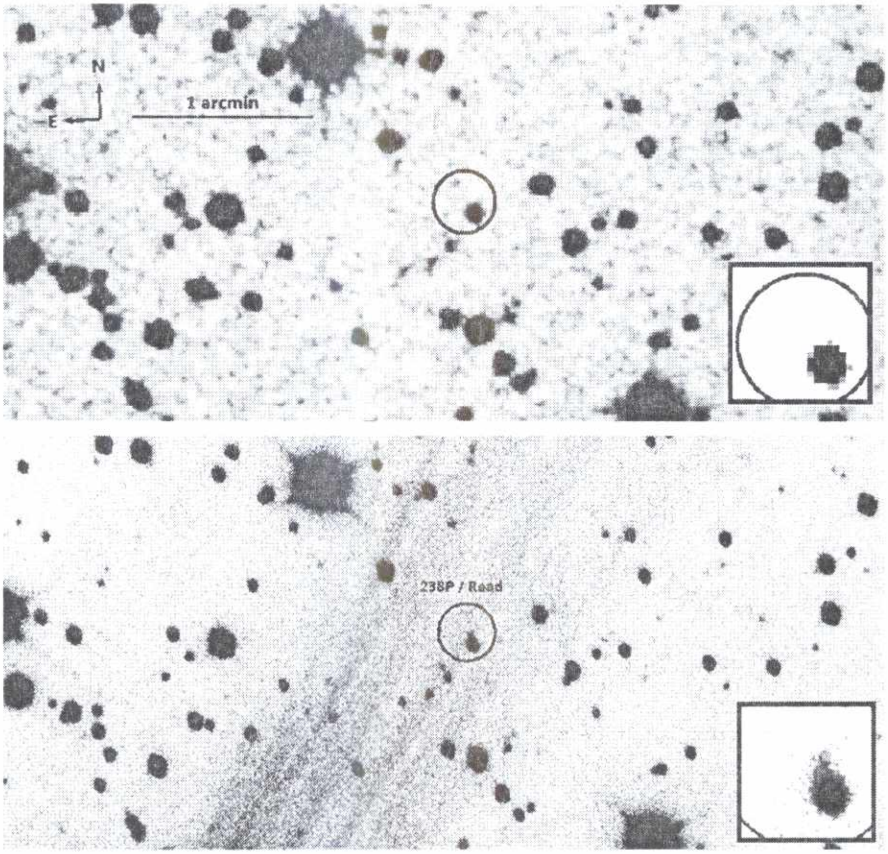

Figure 1: Zoom-in on the field where READ/238P MBC was detected in the night of $30^{th}/31^{st}$ of October. The R filter was used with total of 20 minutes exposure time.

other MBCs (176P/Linear and P/2010 R2) but failed to detect any of them. It seems that additional observations with much longer exposure times are needed in order to detect and study these objects with the telescope of this aperture.

4. CONCLUSIONS

We have conducted a collaborative observing session using MONET/North telescope with three participating groups of high-school students (from Croatia, Greece and Serbia). The Serbian group, consisting of eight high-school students, attempted photometric observations of there MBC objects: 176P/Linear, 238P/Read and P/2010 R2. We have been able to detect only 238P/Read in our data. In our best data stack of 20 minutes of exposure time in the R photometric band, the position of the 238P/Read at the time of observation was near a bright foreground star, which prevented our attempts at precise photometry and we were not able to place any constraints on the presence of a cometary tail.

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PECULIARITIES OF IONOSPHERIC RESPONSE TO SOLAR ERUPTIVE EVENTS

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Abstract. Solar eruptive events such as flares and coronal mass ejections (CMEs) affect the terrestrial upper atmosphere, the magnetosphere and ionosphere in particular, through sudden impacts of additional X-ray radiation and by increased intensity of the solar wind. As a consequence, a variety perturbation features occur locally as well as globally in the plasma medium in space around the Earth. We study some of such transient phenomena taking place at low altitudes of the ionosphere (below 90 km) by monitoring and analyzing registered amplitude and phase time variations of VLF radio waves with given frequencies. The main object of this research is gaining an additional insight into the structure and physical properties of the lower ionosphere.

1. INTRODUCTION

The terrestrial atmosphere is a medium of a highly complex nature concerning its numerous physical and chemical processes occurring on different spatial and temporal scales, and being induced by various phenomena such as large scale atmospheric storms, electric discharges in lightnings, atmospheric convective motions, meteorite passages through the atmosphere, and magnetic storms, tectonic motions coming from the interior of the Earth, ocean motions like tsunamis, local effects of the sunrise and sunset, solar eclipses, and a broad set of solar activity features such as CMEs, solar wind, and solar flares of intense electromagnetic radiation. All these features cause atmospheric disturbances ranging from perturbations in the geomagnetic field and excitation of waves and electric currents at very high altitudes (up to several Earth radii) in the plasmasphere, to time-varying atomic processes and formation of nonstationary free-electron layers in the ionosphere at relatively lower altitudes (from 60 km to over 1000 km). All these induced processes are mutually more or less coupled and form a unique dynamic system that became a subject of diverse studies in the fields of theoretical meteorology and aeronomy, as well as in many technical applications related radio-communications and GPS technology among others.

Our research is focussed on processes in the low ionosphere at altitudes below 90 km where the ground emitted very-low-frequency (VLF) radio waves are being deflected from a local free-electron layer and then registered by a world-wide system of receivers (the Atmospheric Weather Electromagnetic System for Observation Modeling and Education - AWESOME) with one of them located in Institute of Physics, Belgrade, Serbia. Time variations of the registered VLF wave amplitude and phase are signatures of induced physical processes at the height of wave-deflection allowing us to estimate both the paths of the electron production kinetics and excitations of hydrodynamic waves.

In this contribution we analyze the low ionospheric reaction to the solar X-flare event from May 5, 2010 that caused a strong transient increase in the ionizing X-ray emission which affected amplitude and phase time variations of the VLF signal emitted by the DHO transmitter (in Germany) at frequency 23.4 kHz and recorded by the AWESOME receiver in Institute of Physics, Belgrade, Serbia.

2. THE RECORDED WAVE AMPLITUDE ANALISIS

The considered solar X-ray burst (May 5, 2010) was recorded by the GOES-15 satellite as a peak in the radiation intensity at 11:52 UT as seen in Fig. 1, the top panel. This X-ray emission rise affects the amplitude $A(t)$ of the recorded VLF wave in a way seen in the lower panel of the same figure. The profile shape of this transient perturbation of the wave amplitude reveals some of the basic physical properties of the lower ionosphere.

First, the time profile of the recorded VLF wave amplitude is Fourier analyzed (Čadež et al. 2009) as:

$$A_F(T) = \frac{1}{\sqrt{2\pi}} \int_{-\infty}^{\infty} \mathrm{e}^{-2\pi t/T} \mathrm{A(t)dt} \qquad (1)$$

which gives global and local oscillation spectra of harmonic motions of the lower ionosphere. As seen in Fig. 2, the most pronounced periods are grouped about T = 0.2 s, T = 1 s, T = 10 s, and T = 200-600 related to the class Pc1 pulsations in addition to somewhat less intense Pc2-Pc3 and Pc5 pulsations. Also, low frequency magnetohydrodynamic (MHD) fluctuations were found to exist high in magnetospheric regions both experimentally and in numerical simulations (De Keyser and Čadež, 2001 a, b) as externally driven (by the solar wind) modes with typical periods ranging from couple of seconds to more than 1000 s. These MHD waves can eassily be transmitted to the lower parts of the ionosphere where they show up predominantly as gravito-acoustic modes.

Second, the analysis of the profile $A(t)$, as done in Nina et al. (2011, 2012), allows for modeling the kinetics of electron generation by the X-ray emission:

$$\frac{dN(t,h)}{dt} = K(t,h)I(t) - \alpha_{\text{eff}}(t,h)N^2(t,h) \qquad (2)$$

and, consequently, determination of both the electron density $N(t,h)$ and the effective recombination coefficient $\alpha_{\text{eff}}(t,h)$ in time t and at different heights h as shown in Fig. 3.

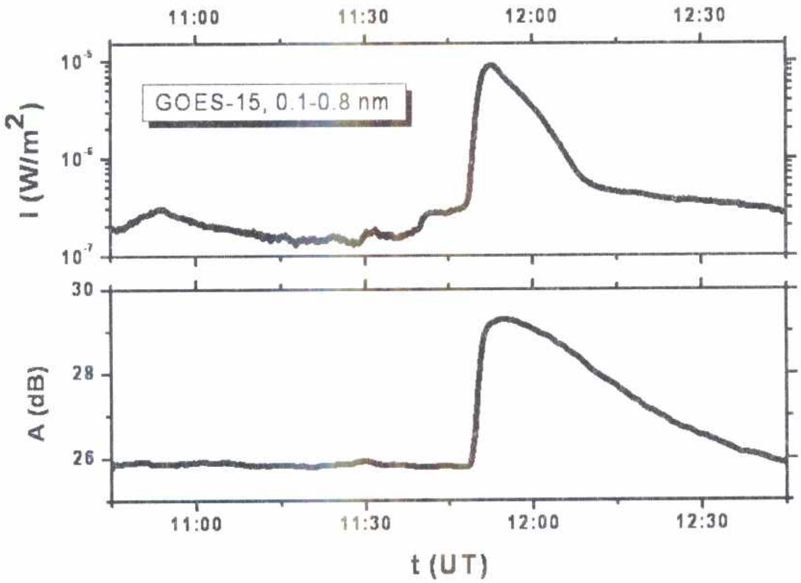

Figure 1: Time variation of the radiation intensity registered by the GOES-15 satellite (top panel) and signal amplitude (expressed in dB) recorded by the AWESOME receiver located in the Institute of Physics in Belgrade.

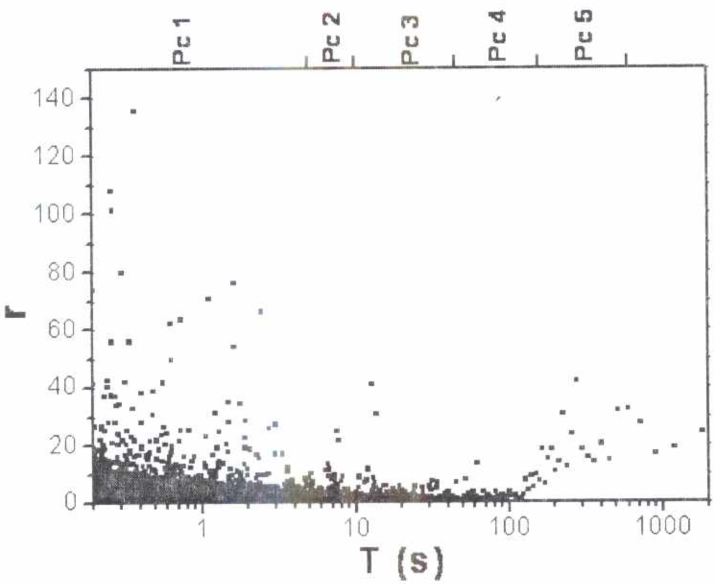

Figure 2: Normalized Fourier transformed VLF signal amplitude vs oscillation period T.

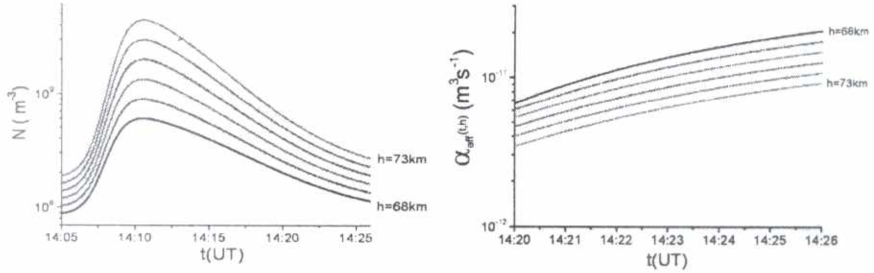

Figure 3: Resulting time distribution of electron concentration $N(t,h)$ (left) and effective recombination coefficient $\alpha_{\text{eff}}(t,h)$ (right).

3. CONCLUSION

Solar X-ray bursts are just one of many features that cause disturbances and leave consequences throughout the terrestrial atmosphere. Some of them are recognized as characteristic peculiarities in recorded VLF radio wave amplitude time profiles $A(t)$ typical of the perturbation source and physical properties of the lower ionosphere where the VLF waves are being deflected toward the ground receivers. Analyses of the recorded data on $A(t)$ thus enable us to recover some of physical properties of the low ionosphere such as characteristic wave motions of the local plasma, and kinetics of time evolution of the net free electron production. The monitoring and analysis of the recorded VLF radio waves therefore proves to be a useful tools to study not only the processes and physical properties in the lower ionosphere but also their relations to those elsewhere in the atmosphere. Moreover, these studies are also applicable to space weather research activities as they contribute to a better understanding of global consequences of solar activity induced in the terrestrial environment in general.

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Publ. Astron. Obs. Belgrade No. 92 (2013), 161 - 164 *Poster*

CCD OBSERVATIONS OF ERS WITH THE 60 cm TELESCOPE AT ASV

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Abstract. We present the observations of extragalactic radio sources (ERS) which are possible in the optical domain and can be used to establish the link between the ICRF2 and the future Gaia Celestial Reference Frame (GCRF). Our telescope of small aperture size (<1 m) is located in the south of Serbia, near the town of Prokuplje, at the Astronomical Station Vidojevica (ASV) which belongs to the Astronomical Observatory of Belgrade (AOB). It is a Cassegrain-type optical system (D=60 cm, F=600 cm) of equatorial mount. About 40 ERS, from ICRF2 list, were observed at ASV during 2011 and 2012. These observations are of importance to compare the ERS optical and radio positions (VLBI ones), and to investigate the relation between optical and radio reference frames. Also, they are useful to check the possibilities of the instrument. We observed ERS with the CCD Apogeee Alta U42. The observations, reduction and preliminary results of some ERS are presented here.

1. INTRODUCTION

During last few years, astrometry with ground based optical telescopes has become a modern topic, and it is in line with the GAIA mission for: the future astrometric monitoring of GAIA, the link between radio and optical positions of ERS, the realization of a catalogue of quasars, etc.

The International Celestial Reference Frame (ICRF1) was adopted by the IAU in 1997 (the IAU XXIII GA, Kyoto). It is defined by the measured positions of 212 extragalactic radio sources, mainly quasars, by using VLBI. The ERS are assumed to provide fixed (quasi-inertial) directions in space. The ICRF1 replaced the optical FK5 reference frame on January 1, 1998. The second realization, ICRF2, was adopted at the IAU XXVII GA (2009, Rio de Janeiro); there are the precise positions for 3414 radio sources (295 "defining" and 3119 additional ones). The two largest weaknesses of ICRF1 were eliminated: more uniform sky distribution of ERS and the position stability of the 295 ICRF2 defining sources. On the other hand, the Hipparcos Celestial Reference Frame (HCRF) is an optical one. It was linked to the ICRF (radio one), but the accuracy decreases over time because of the error in the proper motions of stars, and it is necessary to verify and refine the relation between the HCRF and ICRF2 by using different telescopes and methods. To align the radio frame (ICRF2) and optical frame (HCRF) with high accuracy, we need to observe the common objects, ERS, and to calculate their accurate optical positions.

The task of ICRF2 is obtaining the coordinates of quasars as accurately as possible, and to determine the precise coordinates of moving objects (stars, planets, etc.). The ICRF2 consists of the precise coordinates of compact ERS, mostly quasars; their current positions are known to be better than 1 mas. From time to time, it is necessary to analyze the accurate observational VLBI data concerning ERS at radio wavelengths and the CCD ones obtained by telescopes in the optical domain.

The frame stability is based upon the assumption that the proper motions of ERS are negligible. But, due to their active nuclei, there is a structural instability of the sources at radio and optical wavelengths. On the other hand, a regular maintenance of the system and improvement of the frame are necessary. Because of it, the optical telescopes are useful to monitor the magnitude and morphology of some ERS. The morphology of ERS is studied using the data obtained with medium size aperture (1 m to 2 m) telescopes, but in photometrical studies we can use the data from small aperture size (< 1 m) telescopes, such as our telescope at ASV.

The telescope position is: longitude $\lambda = 21^\circ 33' 20''\!.4$, latitude $\varphi = 43^\circ 8' 24''\!.6$ and altitude $h = 1150$ m. It has a German equatorial mount and a Cassegrain optical system with optical elements produced by LOMO company (St. Petersburg, Russia). The primary mirror is parabolic with a diameter $D = 60$ cm and the secondary one is hyperbolic with $D = 20$ cm; it is a classical Cassegrain optical system. The telescope focal length is 600 cm. The main characteristics of CCD camera Apogee Alta U42 are: the size of CCD chip is 2048 × 2048 pixels, pixel size is $13.5 \times 13.5 \mu m$ and field of view (FOV) is about $15.'8 \times 15.'8$. The angle corresponding to one pixel is $0''\!.46$.

2. OBSERVATIONS AND RESULTS

It is possible to investigate the relationship between optical and radio frames using the differences between optical and radio coordinates ($(\text{O-R})_\alpha$, $(\text{O-R})_\delta$) of ERS. We observed ERS with the CCD camera Apogeee Alta U42 attached to 60 cm telescope at ASV during 2011 and 2012. About 40 ERS were observed from the ICRF2 list (Fey at al. 2009).

Here, the positions (α, δ) of the optical counterparts to ERS were determined and the relative method was applied by using the coordinates and proper motions of stars from the XPM catalogue compiled by Fedorov et al. (2010). XPM contains data for 314 million stars distributed all over the sky for the epoch J2000.0. It contains much more stars than the Hipparcos Catalogue which makes it possible to have enough stars within a small field of view.

Here, we present results for 6 optical counterparts of ERS from the ICRF2 list (Table 1): L 0109+224 (J011205.8+224438), A 0059+581 (J010245.7+ 582411), Q 2250+190 (J225307.3+194234), G 0007+106 (J001031.0+105829), L 2254+074 (J225717.3+074312) and G 0309+441 (J031301.9+412001). The designations outside the parentheses are ICRF ones, within them the IERS[1] designations are used. We made 6 frames per ERS (3 at R filter and 3 at V one), and $14.2 \leq m_V \leq 17.0$. For each frame, the exposure time was 60^s and all exposures were guided. The corrections for apparent displacements, as differential refraction (Aslan et al. 2010, Kiselev 1989), and the reduction on bias, dark and flat-field were not applied. Designations of the

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[1] International Earth Rotation Service

Table 1: Observed ERS: L - BL Lac, A - active galactic nuclei or quasar, Q - quasar, G - galaxy.

Type of ERS and name	α_{ICRF2} [h m s]	δ_{ICRF2} [° ′ ″]	V mag	Exp [s]
L 0109+224	01 12 05.825	22 44 38.786	16.4	60
A 0059+581	01 02 45.762	58 24 11.137	16.1	60
Q 2250+190	22 53 07.369	19 42 34.629	16.7	60
G 0007+106	00 10 31.006	10 58 29.504	14.2	60
L 2254+074	22 57 17.303	07 43 12.302	17.0	60
G 0309+441	03 13 01.962	41 20 01.184	16.5	60

columns in Table 1 are: the source name and type of object, the ICRF2 coordinates (α, δ) of ERS, the V magnitude and the exposure time.

For processing the CCD images, the first step is to detect the star-like object (ERS) and reference stars. The Fortran program for reduction of stellar apparent coordinates is written with some procedures from SOFA packages (Standards of Fundamental Astronomy). The next step is the measuring the CCD positions (x, y) of ERS and stars. The linear model was used, as a standard astrometric "plate" reduction, with the available reference stars, $\xi = ax + by + c$ and $\eta = dx + ey + f$ (Kiselev 1989), to transform the measured CCD coordinates (x, y) to tangential ones (ξ, η). Because of small FOV, the tangential coordinates of reference stars and ERS are equal to the equatorial ones (Aslan et al. 2010). The unweighted Least - Squares Method (LSM) was used to calculate the unknown values of parameters a, b, c to get α, and d, e, f to get δ. To do that we need at least 3 reference stars. The AIP4WIN (Berry & Burnell 2002) image processing package was applied to the CCD data. Thus, the optical coordinates of 6 mentioned ERS objects were determined. Finally, we compared our optical (O) positions of ERS with the radio (R) ones to determine the values (O-R) in α and δ (see the results in Table 2). We used the VLBI radio coordinates from IERS Technical Note No. 35 (Fey at al. 2009).

Our results have been compared with those of Maigurova and Damljanović (2011) and a good agreement has been found.

The same objects were observed also at Rozhen with the 2 m telescope (Damljanović and Milić 2012) and the resulting coordinate differences are comparable.

3. CONCLUSIONS

The presented preliminary results (in α and δ) and their standard errors for the 6 observed ERS objects obtained with the 60 cm telescope at ASV agree well with the results obtained with the larger Rozhen telescope. Also, these results are useful for improving the coordinates and proper motions of reference stars contained in the XPM catalogue and to calculate the unknown position of every star in the neighborhood of ERS. Using dark, bias, flat frames and stacking during the reduction of CCD images, we expect better results of (O-R) in positions of ERS. Also, the ASV results could be improved with star guider (to use the exposures longer than 90 sec). The small

Table 2: Differences between optical and radio coordinates $(O-R)_\alpha$ and $(O-R)_\delta$ for ERS and their standard errors

Name of ERS	(O-R)$_\alpha$ [″]	(O-R)$_\delta$ [″]	σ_α [″]	σ_δ [″]
L 0109+224	–0.049	–0.036	0.138	0.158
A 0059+581	0.026	0.317	0.226	0.495
Q 2250+190	–0.181	0.224	0.400	0.120
G 0007+106	–0.115	0.053	0.038	0.076
L 2254+074	0.145	0.180	0.381	0.556
G 0309+441	0.064	–0.353	0.315	0.263

telescope at ASV practically does not allow observations of faint objects (fainter than about $m_V = 18$).

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Publ. Astron. Obs. Belgrade No. 92 (2013), 165 - 168 *Poster*

MONITORING EXOPLANETS FROM ANTARCTICA WITH ICE-T

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Abstract. The International Concordia Explorer Telescope (ICE-T) is a f/1.1 Schmidt telescope, 61 cm aperture, with two tubes equipped with identical CCD 10.3×10.3k, 9μ ultra-wide-field with a total FOV of 65 square degrees. Its aim is to operate at Dome C, the French-Italian Antarctic Station, taking advantage of the long winter night for continuous observations. It is optimized for high precision photometry in two separate filters Sloan g and Sloan i ranging from 100μmag to 10 mmag (9-16 mag). Among the scientific tasks there are the detection of hot Jupiters and Super Earths with the transit method, and related magnetic activity of the hosting stars. The 4m Radom for ICE-T together with 3 foundation pillars and the cables bundle have been already successfully installed in January 2009.

1. MOTIVATION

ICE-T is an international consortium led by the Leibniz Institut für Astrophysik Potsdam foreseen to be located at the French Italian Concordia Station at Dome C (72°06'04" S, 123°20'52" E, 3233 m altitude). Dome C is well known to be one of the best sites in the world for observations because of sky transparency in most of the atmospheric windows, low sky background (typically from 3 to 5 times lower than at mid latitudes), very good seeing (0.27 arcsec above 30 m), higher isoplanatic angle (5.7 arcsec), longer coherence time (7.9 ms), even better than at South Pole (Agabi et al. 2005), and low scintillation noise which permits to reach a photometric precision of 200μmag.

The prime envisioned scientific targets are extra-solar planets as well as stellar magnetic activity and non-radial pulsations in the structure of the host star, their inner dynamics and dynamo activity too (Strassmeier et al. 2008). Long term observations with high precision are necessary to detect planets and to analyze starspots and flares. We need two separate bandpasses, Sloan g (402-552 nm) and i (691-818 nm) operating simultaneously in order to discriminate a transit from spot and plages associated to rotation (Carpano et al. 2003). Optical afterglows of gamma-ray bursts and micro-lensing effects are also pursued among the required targets. ICE-T will stare at one single field for each campaign. Once it is pointed, the telescope is supposed to keep on tracking the very same field in a fixed position along RA for the whole season. Two optimal fields have been selected taking into account the diurnal air mass and refraction variations, solar, lunar interference, interstellar absorption,

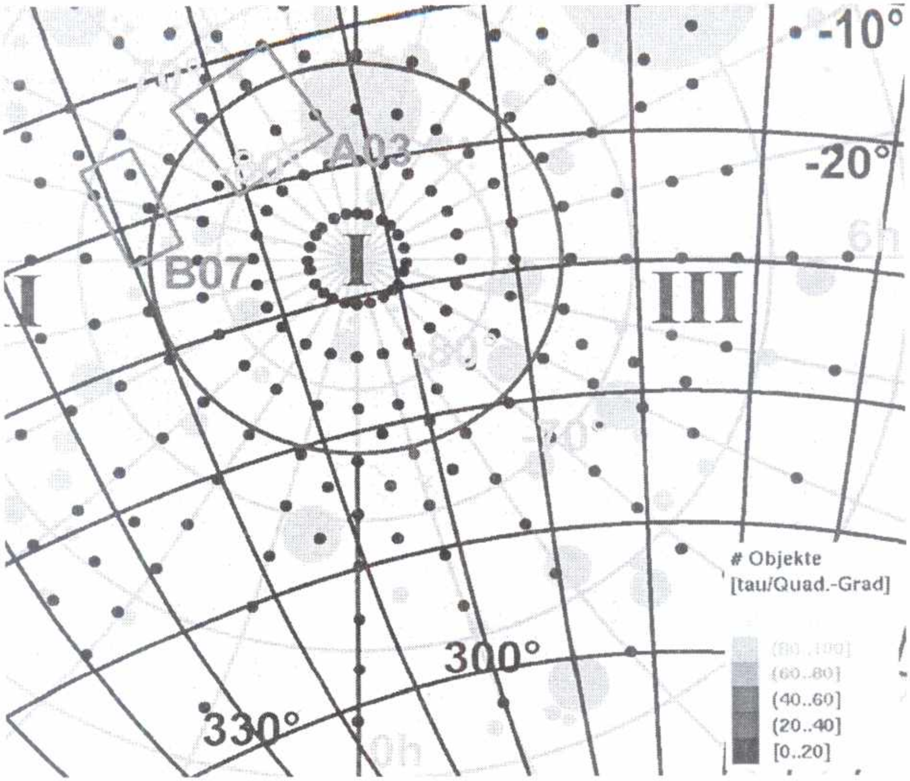

Figure 1: Position of the two optimal fields A03 (in equatorial coordinates α=14^h20^m, δ=-77.0°) and B07 (α=17^h04^m, δ=-73.3°). Black dots represent the number of stars in a square degree down to 18.5 mag. The light blue areas are either star-forming regions, dark clouds or open clusters. The small blue dots are known variable stars taken from the catalogue GCVS. Regions enclosed by I are located close to zenith with declination lower than the geographical latitude of Dome C. Fields contained by region II are affected by full moon, and those in region III are in the direction of the sun (Fügner et al. 2008).

overexposing of bright stars and ghosts, crowding by background stars, and the ratio of dwarf to giant stars in the field. A03 and B07 are respectively the best full-frame and half frame fields (8.1°×8.1° and 8.1°×4.05°), so that open clusters, dark clouds, star-birth regions and variable stars are minimized within this areas (see Figure 1). Fields in II are in the direction of full moon, while sector III is perturbed by twilight stars. Stars in region I are permanently close to zenith or at most 30° away. Figure 2 represents the position of the two optimal fields in the sky, with respect to the stars hosting so far discovered planetary systems (source: exoplanets.org).

2. OPTICS

The optical system includes a double achromatic Schmidt plate of N-BK7 and N-F2, fast f/1.125, with a 61 cm clear aperture, 20 mm air gap. The main mirror

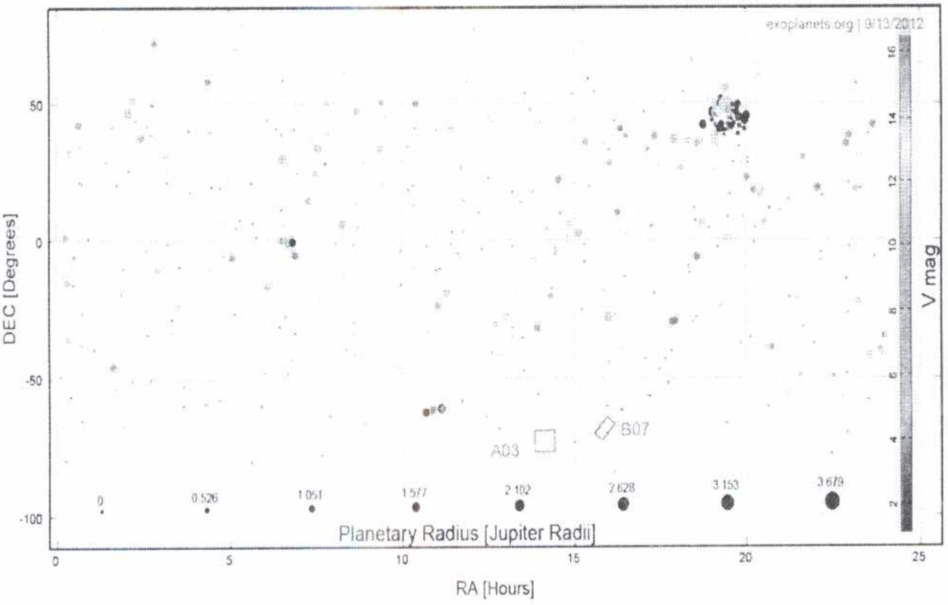

Figure 2: Location of the two optimal fields in the sky, where the dots represent the size of the so far discovered planet (September 2012) in the V-band. Notice that in these regions there is still a lack of information.

made of Zerodur is spherical, Ø82 cm, with a central hole of 15 cm and radius of curvature of 1414.5 mm. A field flattener lens diffracts approximately 16% of the entrance aperture. The triplet lenses, made of BK7 have spherical surfaces with slightly different parameters for Sloan g and Sloan i filters. They are made of N-BK7 glass, as no transmission in UV is required.

The best spot diagram size simulated is 9μ at 400nm. Among five offers from several vendors we have considered only the one from GOAL (General Optics Asia Limited) affordable. The proposal includes manufacturing within 0.5λ P-V and 0.05λ rms tolerances, polishing, light weighting of the primary, coating and delivery. For the primary mirror a surface quality over clear aperture of 0.25λ P-V (λ=632.8 nm), 0.07λ rms can be achieved, via Al+SiO_2 coating. The specification for Antireflection Coating is Single Layer MgF_2. In order to get good adhesion, the substrates are maintained at 300°C during coating. At such elevated temperature, the substrate permanently deforms (degrading optical surface quality beyond acceptable limits). The deformation is enhanced by increasing the aspect ratio (diameter-center thickness).

As the corrector plates have adverse aspect ratio (610/30=20.3), the coating needs to be done at lower substrate temperature. Therefore a multilayer (SiO_2 + Ti_3O_5) AR coating has been proposed.

3. CCDs

We intend to use two CCDs without shutter, i.e. in frame-transfer mode as was foreseen for ESA's Eddington mission. Read-out is then retrieved during exposure,

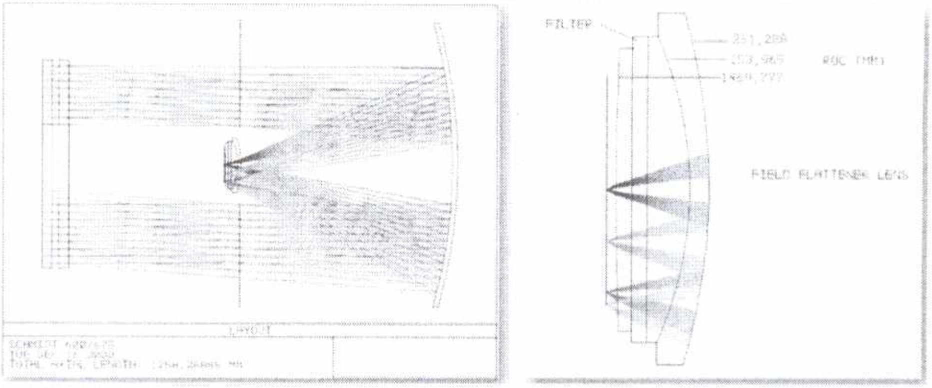

Figure 3: Left: Optical layout in Sloan *g*. Right: Triplet lens Ø180 mm, constituting the field flattener, with the filter inserted inside the positive lens, and the last lens being the dewar entrance window.

which sets the time resolution nearly to the exposure time. The total unvignetted FOV is matched to the 95 mm×95 mm thinned STA1600A CCD. A FOV of 8.1°×8.1° with 10600^2 pixels correspond to 2.75 arcsec/pixel. The architecture of the STA1600A CCDs includes a total of 16 amplifiers, 8 on each adjacent side. The read-out-noise of the STA device with an ARC Gen-II controller is expected to be similar to the first PEPSI STA 10k device at 200 kpix/port/s (≈ 7 e^-). Frame transfer operation will relax the controller requirements to ≈ 350 kpix/port/s for a 10s integration without a waiting period (Strassmeier et al. 2010).

4. THE DOME STRUCTURE

The Rader dome, built by *Baader Planetarium*, whose inner diameter is 3.4 m, can be fully opened. It is bolted on a wooden platform, with an elevation of 1 m above the ground. The platform has a central aperture of Ø1.8 m to host three Ø600 mm concrete piers, on which the weight of the telescope is distributed. Overall weight is estimated to be at most 3 tons. The piers have a length of 4m of which 3m are plunged into the ice. The Dome and the platform have been successfully installed at Dome C at the beginning of 2009 and site access has been granted by French polar agency IPEV since October 2010.

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PARSES PIPELINE FOR DETERMINING THE STELLAR PARAMETERS

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Abstract. PARSES is a pipeline for determining physical parameters of a star from the stellar spectra – effective temperature, metallicity, surface gravity and rotational velocity. It utilizes the grid of templates based on synthetic spectra, and the search routine is based on the Minimum Distance Method. In order to calibrate the routine, we tested it with different wavelength ranges used for fitting the observed spectra. Results for stellar parameters are compared with the literature values from the ELODIE library. The last step was to choose final solution for full implementation on the data produced with the STELLA telescope. The modified version of the pipeline is going to be used in processing the data from the ELODIE spectral library and also tested on some Gaia ESO data.

1. INTRODUCTION

Robotic and semi-robotic telescopes are automatically followed by unsupervised data reduction pipelines and automated analysis. PARSES is a pipeline for automatic determination of the stellar parameters from stellar spectra. In this paper we are presenting work-in-progress on its future implementation on spectra obtained using the STELLA robotic observatory[1]. The STELLA robotic observatory hosts the STELLA Échelle spectrograph (SES), which has been successfully in operation since 2006. SES is producing high-resolution spectra covering the visual wavelength range covering from 3850 to 8700 Å at a resolution of 55 000. The spectra are consisting of 82 slightly overlapping orders.

The pipeline is planned for determination of four parameters – metallicity [Fe/H], projection of rotational velocity $V \sin i$, effective temperature $T_{\rm eff}$ and surface gravity $\log g$.

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[1] `http://www.aip.de/stella`

2. METHODOLOGY

The classical method for quantification of physical parameters of a star from its spectra has been performed by measuring the equivalent width of lines and comparing it to a model-based computed spectra. Robotic dedicated spectroscopic surveys require faster methods which mainly use tables of synthetic spectra.

The grid of synthetic spectra we used was based on the newest MARCS model atmospheres (Gustafsson et al. 2008).
The parameter range for the grid was following:

- effective temperature $T_{\rm eff}$: (3000 – 7000) K, step 250 K,
- surface gravity $\log g$: (0 – 5.5), step 0.5,
- metallicity [Fe/H] : (−2.5 – 1.0) dex, step 0.25 dex,
- projected rotational velocity $V \sin i$: (0 – 150) km/s, scale is logarithmic.

The synthetic spectra were built using the code Turbospectrum (Alvarez and Plez 1998, Plez 2012). The line-list used by Turbospectrum was the most up-to-date and comprehensive atomic line-list called VALD3 (Kupka et al. 2000). The stars observed with SES are cold (mainly K, G and F), and some of them are expected to have strong molecular lines, for example, some Titanium oxides lines. The tests were done using molecular lines but no significant differences were found. The synthetic spectra in our grid are built using only atomic lines. In order to get rectangular grid of models, the holes and edges are filled by calculating the model flux through interpolation and extrapolation respectively. The synthetic spectra are then convolved with the instrument profile of SES. We concluded that in the final grid of model fluxes microturbulence can be fixed to one or two values, based on the relatively small range of parameters (and spectral types) of the stars observed with SES. Of course, there is a possibility of adding (or subtracting) a parameter to the grid, one of them being the microturbulence. Broadening due to macroturbulence is also added (values from Gray 1992). Broadening due to rotation is not applied on spectra in three-dimensional case. Continuum normalization is done for both acquired and calculated spectra.

Wavelength ranges in which the observed spectra will be fitted with the synthetic one are specified in the input file used by the pipeline – database file.

Input empirical spectra obtained by SES have been reduced beforehand (also using a pipeline) in the usual manner. Radial velocity pipeline is also operational and it was used to apply a correction for radial velocities.

For the analysis of the observed spectra PARSES uses a method which belongs to the type of Minimum Distance Methods (also stands for Metric Distance Minimization). MDMs are based on the simple concept of maximizing the agreement between observed and the model fluxes (flux is some function of physical parameters here) by defining some sort of distance. Direct χ^2 minimisation, which is a type of MDM, has been performed for evaluation of the distance between an observed and computed spectra. To reduce the number of evaluations of the distance, a non-linear simplex optimization method (see Nelder and Mead 1965) was used. Significant improvements in precision are achieved by using interpolation. Interpolation is performed in the flux space, so the model flux becomes a continuous function of the parameters, and then optimization methods can be employed. The cubic Bézier model flux interpolation from a multi-dimensional grid was interpolation used here.

3. CALIBRATION

Testing of the different input files for the pipeline – database files – was the main part of the calibration procedure. Six different versions of the pipeline were run on a sample of 262 spectra of 29 stars observed with SES, and the comparison with the literature values given in the ELODIE library[2] was done. The database files are made of a grid of synthetic spectra and spectral ranges used for fitting.
The basic features of different database files are as follows:

1. The first version of the pipeline used only eighteen orders from the échelle spectra. The orders used are in the blue part of the spectra. The grid is four-dimensional in this case so it includes rotational velocity. Temperature is truncated at 5000 K. The spectra in the grid are based on the Kurucz models (Kurucz 1993).

2. The second version used the same orders as the first one, but the grid was three-dimensional (without a projected rotational velocity), and the model atmospheres were MARCS. The temperature range was 4000 – 7000 K, and we fixed microturbulence ξ_t value to 2.

3. The ranges for the third one are the same as in the radial velocity pipeline for SES - 62 orders.

4. The fourth version has been done in the most elaborate manner. A star that was both well-documented in the literature and has also been observed with SES was chosen, and that was HD 212943. We built a small grid of the synthetic spectra based on the MARCS models, and just by using the search routine we have found the synthetic spectra that is closest to the observed high signal-to-noise spectra. Visual inspection of the observed and synthetic over-plotted spectra gave us a final assessment of the usable regions – 73 wavelength ranges in 62 orders were chosen. Regions with strong telluric lines, high noise and Hα-line were omitted. Two different values for the microturbulence were used, $\xi_t = 1$ for $\log g \geq 3.5$, $\xi_t = 2$ for $\log g < 3.5$.

5. This was a red subset of the orders used in the third version, 41 of them.

6. Same as the version three above, but with two different values for the microturbulence: $\xi_t = 1$ for $\log g \geq 3.5$ and $\xi_t = 2$ for $\log g < 3.5$.

In order to test and represent the quality of the results produced with PARSES we had to compare it to parameter values given in the literature or produced by some other pipeline. In the initial stage we planned to use the values inferred from the spectra in the ELODIE spectral library. The ELODIE spectral library has been chosen for comparison because of the similarities between the spectrographs used,

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[2] `http://http://atlas.obs-hp.fr/elodie/intro.html`

Table 1: σ (estimated standard error of regression) and r (correlation coefficient) are given as statistical measures of the agreement between parameter values calculated by PARSES pipeline (x-axes) and literature parameter values from the ELODIE library (y-axes). These parameters are given for the six different databases (input files) that were used by the pipeline.

dbNo.	$\sigma_{T_{\rm eff}}$ [K]	$r_{T_{\rm eff}}$	$\sigma_{[{\rm Fe/H}]}$ [dex]	$r_{[{\rm Fe/H}]}$	$\sigma_{\log g}$	$r_{\log g}$
1	440.684	0.78323	0.422591	0.851709	0.86179	0.814176
2	142.880	0.97947	0.114268	0.989911	0.54270	0.930759
3	135.449	0.98157	0.106560	0.991232	0.51096	0.938877
4	206.719	0.95653	0.162290	0.979542	0.72844	0.871289
5	126.532	0.98394	0.116162	0.989572	0.53074	0.933882
6	135.658	0.98152	0.108929	0.990836	0.50882	0.939405

their resolution, the wavelength ranges and the selection of targets. Because of the lack of parameter values determined independently by a pipeline on the ELODIE spectra (subject of ongoing work), comparison with the literature values given by the ELODIE are presented here.

PARSES has been run on the sample of stars cross-matched with the ELODIE library. Where possible 10 SES spectra with highest S/N for each sample star were used, and preferably from different years of observation. Different periods of observation have been used because there were some modifications of the reduction procedures. PARSES has been run on every spectra and using all six different versions of the grid and spectral ranges – databases from No.1 to No.6.

The results from the pipeline were plotted against the ELODIE literature values for $T_{\rm eff}$, [Fe/H] and $\log g$. The data has been fitted with the regression line.

In order to evaluate the agreement between parameter values produced by PARSES and the literature, some statistical criteria were employed. The estimated standard error of regression and Pearson's correlation coefficient were calculated (see Table 1). Here standard error of regression is a square root of the sum of the squared residuals divided by the number of degrees of freedom.

We have built four-dimensional grids for the spectral ranges and other settings from the third and the fourth version. We ran the pipeline on the four-dimensional (4D) grids using the settings described earlier. The fourth parameter in the grid was a projection of the rotational velocity $V \sin i$, as it is usually given in the literature. The estimated standard error of fitted regression line σ and correlation coefficient r for a 4D case of databases No.3 and No.4 are given in Table 2. The plot representing agreement between parameters calculated on the four-dimensional version of the grid with database No.4 settings and values given in the literature can be seen in Figure 1. Errors are not shown in the plots here and their more accurate determination is a subject of an ongoing work.

The results are different for 3D and 4D case which is expected because of the degeneracies between the parameters, among other things. For example, we expected $V \sin i$ and the difference between the parameter value obtained with 3D and 4D pipeline to be correlated. No clear trend was found. The plot representing the differences for surface gravity plotted against $V \sin i$ can be seen in Figure 2.

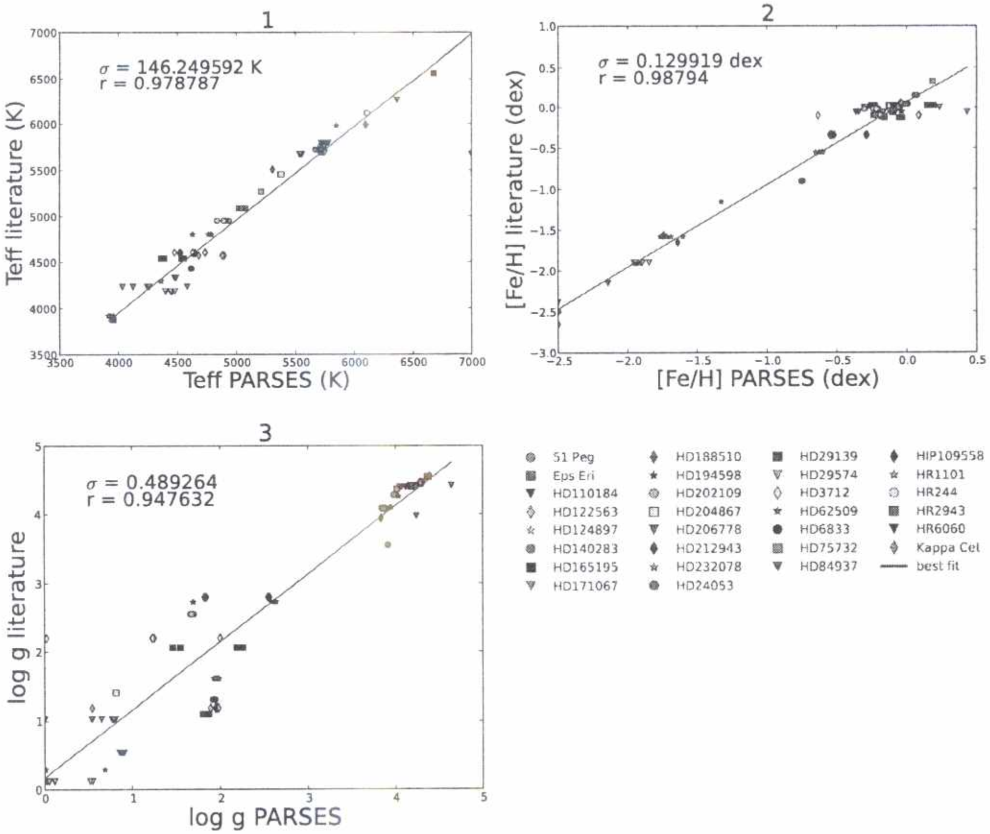

Figure 1: The results from No.4 4D database PARSES plotted against the ELODIE literature values for the same stars. Plots No.1, 2 and 3 show effective temperature, metallicity and surface gravity, respectively. The estimated standard error of regression σ and correlation coefficient r are given in the plot.

Table 2: The estimated standard error of the fitted regression line σ and correlation coefficient r for the data points that are representing parameter values given by PARSES pipeline (x-axes) and literature value given by the ELODIE library (y-axes). These parameters are given for the four-dimensional case of databases No.3 and No.4.

dbNo.	$\sigma_{\mathrm{T_{eff}}}$[K]	$r_{\mathrm{T_{eff}}}$	$\sigma_{[\mathrm{Fe/H}]}$[dex]	$r_{[\mathrm{Fe/H}]}$	$\sigma_{\log g}$	$r_{\log g}$
3	137.3436	0.981315	0.127274	0.988429	0.425163	0.960719
4	146.2496	0.978787	0.129919	0.987940	0.489264	0.947632

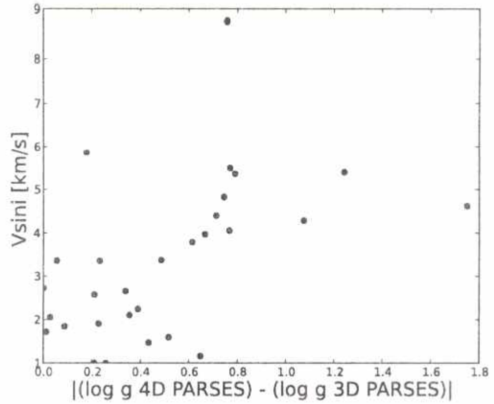

Figure 2: Projection of rotational velocity $V \sin i$ plotted against the difference in determining surface gravity by 3D and 4D pipeline.

The 4d database No.4 is most likely going to be used for final implementation. Testing and further calibration are in progress.

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LUCKY IMAGING AT THE OSKAR-LÜHNING-TELESCOPE IN THE NEAR INFRARED WAVELENGTH RANGE

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Abstract. The performance of the Oskar-Lühning-Telescope at the Observatory of Hamburg in combination with a high-end CMOS camera for high resolution astronomy has been investigated. The observations were made with a CMOS camera that is sensitive to photons in a wavelength range from 0.9μm to 1.7μm. In oder to achieve high resolution imaging the exposure time was chosen such that the atmospheric turbulence was frozen during the exposure. The speckle coherence time was found to be (30 ± 17) ms. From these exposures the best were selected and combined to the final result. To properly calibrate the orientation and the pixel scale of the camera binary systems with known orbital elements have been observed. For the pixel scale a value of (273.7 ± 4.2) mas/Pixel and for the orientation an offset angle of $(0.82 \pm 0.75)^\circ$ have been determined.

1. INTRODUCTION

Establishing a high resolution imaging system for the near infrared wavelength range is promising because the majority of stars in the stellar neighbourhood are of late spectral type. Such a system is especially useful for the recently increased research interest in ultracool dwarfs that have their emission maximum in this wavelength range. Furthermore, direct imaging of binaries whose components are of different spectral types is more feasible because the brightness difference is significantly lower in the near infrared wavelength range than in the visual band. Also components that are overlooked in V band surveys might be imaged in this wavelength range.

In addition, the influence of the atmospheric turbulence is less pronounced. This has two important consequences. First, the probability to obtain only slightly distorted images is exponentially higher for longer wavelength. Second, the turbulence induced atmospheric distortions are subject to longer timescales.

The determination of orbits of binary systems is the only way to determine the masses of stellar objects. This information can verify stellar formation models. The other purpose of resolving binaries is to find massive objects that influence the orbit of exoplanets or that might be misinterpreted as planets.

Relatively bright targets were selected to allow short exposure times as well as a high signal to noise ratio. Several thousand exposures were aquired. From all exposures an average bias/dark frame was subtracted and flat fielding was performed. By visual inspection images were rejected that were obviously deteriorated. The reason was improper reading out of the focal plane array by the camera electronics. The best exposures were selected by their Strehl ratio S. The final result was obtained by shifting the brightest pixel always to the same position and adding up the best images. An example of the potential for significant image quality improvement can be seen in figure 1. The left image shows the result obtained by lucky imaging whereas the right image shows the result that was obtained by just adding up all short exposures without further image processing. The latter is what also long time exposures taken

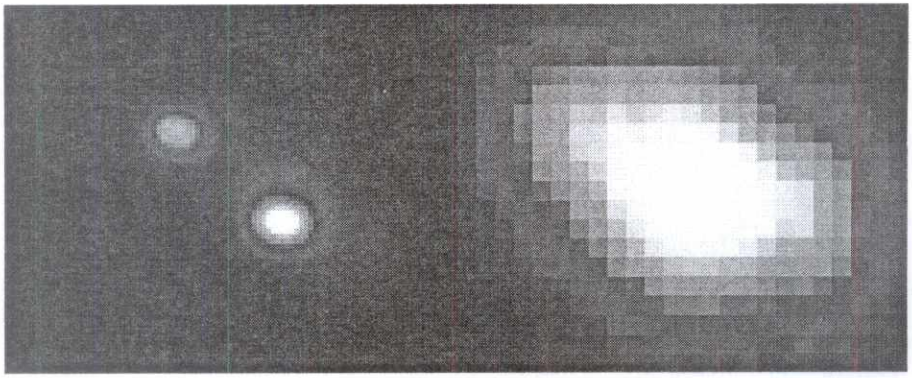

Figure 1: WDS 09184+3522. Distance is 1.″9; north is up and east is to the left.

from ground based telescopes look like. In this case the spatial information is severly degraded while the left image shows clearly the binary system's components.

1. 1. OPTICAL SETUP

The images were aquired with the telescope of the Hamburg Observatory. It is a 1.2 m RC telescope with a focal length of 15.6 m. The focal length of the telescope as well as the pixel size of the camera are fixed. A Barlow lens increases the focal length of the telescope to 23.4 m. It is mounted in a customised adapter that ensures that camera and lens are installed in the correct positions.

1. 2. THE CAMERA

All images were made with an off-the-shelf high-end InGaAs camera with 320×256 pixels manufactured by Xenics. It was chosen because it is able to aquire frames with a maximum framerate of more than 1 kHz for a window of interest of 80×70 pixel.

The camera is equipped with a three-stage thermoelectric cooler that can reach temperatures down to $-52°C$. An operating temperature of $-51°C$ minimises the dark current. For the operating temperature the technical parameters of the camera can be found in table 1. Under the assumption that the total noise is composed of photon and readout noise N_R plus contribution from dark current N_D it can be expressed as

$$\frac{S}{N} \approx \frac{Nt}{\sqrt{Nt + N_D t + N_R^2}} \tag{1}$$

where t denotes the integration time and N the flux. A signal of N=6,500 photons/second and t=30 ms yields to S/N=1.1 which means that the object is too faint to be observed. If N_D and N_R were negligible one would obtain S/N=14.0 which shows that the choice of the detector can significantly influence the magnitude limit.

2. EXPOSURE TIME SELECTION

The choice of the exposure time τ is critical. For the accumulation of a large number of photons it is advantageous to choose τ as long as possible. On the other hand

Table 1: Parameters of the camera at operating temperature.

Parameter	Value
gain	$9,08 \pm 0,31 \frac{e^-}{ADU}$
dark current	$(1,05 \pm 0,20)\, 10^5 \frac{e^-}{s}$
readout noise	$171.5 \pm 12.5e^-$

τ has to be short enough such that the earth's atmosphere is not changing during the exposure. To find a resonable value for τ the time-only variations of the stellar speckles are observed. A large number of images of a bright star have been aquired. In all images the same pixel has been selected and the time-only autocorrelation of its count rate has been evaluated. Theoretically, the autocorrelation $C(t)$ is given by (Aime et al. 1986)

$$C(t) = \frac{2ab}{b^2 + 4\pi^2 t^2} \tag{2}$$

where t denotes the time that elapsed since the aquisition of the first image. Figure 2 compares the theoretical model to the experimental values. From the least squares fit of the data to the experimental values a speckle coherence time of $\tau = (30 \pm 17)$ ms has been determined.

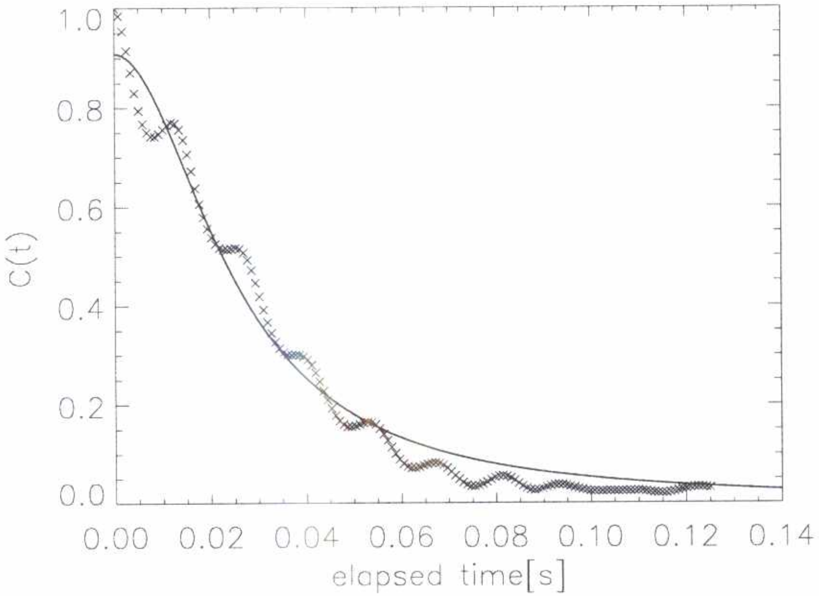

Figure 2: Time-only autocorrelation function $C(t)$ of the stellar speckle pattern. The crosses denote the values derived from the observation of Arcturus and the line denotes the fit to the theoretical model.

3. ASTROMETRIC CALIBRATION

One goal of high resolution imaging is to obtain angular distances ρ and position angles θ of astronomical objects, e.g. double or multiple stellar systems, with the highest possible accuracy. To calibrate the optical setup binary systems with already precisely known orbits were observed. First, the orbital elements as listed in a catalog can be taken to predict ρ and θ for the epoch of observation. In the next step the calculated quantities are compared to the observations. From these observations the pixel scale and the orientation of the camera were derived.

Table 2 lists the designation that is given in the Sixth Catalog of Orbits of Visual Binary Stars (Hartkopf et al. 2001), hereafter VB6, the calculated angular distances ρ_c and position angles θ_c as well as the observed quantities ρ_o(in pixels) and θ_o(in degrees).

Table 2: Comparison of calculated and observed double star parameters

VB6 no.	ρ_c["]	θ_c[°]	ρ_o[Pixel]	θ_o[°]
10200+1950	4.621	126.0	16.81±0.28	125.65±0.88
12244+2535	1.805	323.4	6.13±0.34	328.98±3.07
15038+4739	1.359	62.7	5.51±0.83	54.16±7.67
17053+5428	2.444	5.7	10.34±0.95	9.65±1.64

The calibrators were chosen from the VB6. All calculated quantities refer to the epoch 2012.224.

From table 2 a pixel scale of $(273,7 \pm 4,2)$mas/Pixel and an orientation angle of $(0,82 \pm 0,75)^\circ$ have been determined. The determined uncertainty is consierably greater than the one claimed by another observation campaign. For example an M dwarf survey at the Calar Alto 2.2m telescope has reported a standard deviation for ρ of several milliarc seconds and for θ of less than one degree (Janson et al. 2012)

The designed pixel scale of the optical system was 264.6 mas/Pixel.

4. CONCLUSIONS

Although the results are promising there is still room for improvements. One possibility is the usage of a detector with lower readout noise to increase the limiting magnitude. Second, the optical setup has to be improved because the accuracy of the astrometric calibration is less than the accuracies reported for other calibrations.

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ANALYSIS OF GALACTIC CHEMICAL EVOLUTION MODEL COMPATIBLE WITH MEASUREMENTS OF INTERSTELLAR DEUTERIUM ABUNDANCE

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Abstract. Measurements of interstellar deuterium abundances (D/H) (Copernicus, HST, IMAPS, FUSE) have shown significant variations along different lines of sight. There is correlation between these variations and rates of dust depletion of refractory elements (Fe, Mg, Si), suggesting that differencies in D/H are due to deuterium depletion on dust. Relatively high deuterium abundance ($\sim 70-80\%$ of primordial), according to its destruction in nuclear reactions in stars, is understood as a consequence of constant infall of deuterium rich and low-metallicity gas from the Galactic halo. Furthermore, measurements of gas fraction in baryonic mass of the Galactic disk show that only $7-30\%$ of mass of the disk is in gas. The latest estimates of average D/H abundance in the Galactic disk and primordial D abundance, (used in this paper), together with gas fraction measurements, lead to determination of infall rate as a fraction of star formation rate in simple galactic chemical evolution models. Also, it was determined that return fraction of (deuterium free) gas is $\sim 42\%$ of initial stellar masses.

Presentation link: `http://belissima.aob.rs/Conf2012/Kostic_12.pdf`

Publl. Astron. Obs. Belgrade No. 92 (2013), 181 - 184 *Poster*

ASTRO-CLIMATE: ASTRONOMICAL STATION VIDOJEVICA

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Abstract. The Astronomical Station Vidojevica is located on Mt. Vidojevica near Prokuplje, Serbia. It is selected as the site of the robotic telescope Milanković. The equipment for measuring astro-climate conditions was installed in November 2010. Some preliminary results obtained using the instruments are presented. The results presented here are the part of our long-term monitoring campaign of astro-climate characteristics for this site, which will be useful in planning observations with the future robotic telescope.

1. INTRODUCTION

Astronomical Station Vidojevica, the observing facility of the Astronomical Observatory Belgrade, is located on Mt. Vidojevica near Prokuplje, ($\varphi = 43°08'25'', \lambda = 21°33'20''$), at an elevation of 1150 m. The equipment for systematic measuring campaign aimed to quantify the astro-climate conditions was installed during the winter of 2010/2011. These are Weather station, All-sky camera and Seeing monitor. A detailed characteristics of equipement can be found in papers (Martinović et al. 2013), (Jovanović et al. 2012).

In this poster we present wind speed and direction data (Figure 1) from Weather Station, which is a DAVIS Wireless Vantage Pro 2 with 24-Hour Fan Aspirated Radiation Shield. The weather station is battery and solar-panel powered, therefore it is capable for autonomous measurements and data storage. It proved to be the most stable of all the instruments. Also, we performed preliminary analysis of all-sky camera monitoring in November 2010 and compared estimated cloud coverage (Figure 2) with data from meteorological station Niš ($\varphi = 43°20', \lambda = 21°54'$) at an elevation of 204 m. The camera that we use is SBIG All-Sky 340.

2. RESULTS

We compared our estimate of cloud coverage with data from nearest meteorological station with daily data available, in this case meteorological station Niš. For month of November 2010 we found these data sets agreed within 15%. We are developing an algorithm for automated measurement of the cloud coverage from all sky images.

Important parameters measured with weather station are wind direction and speed. The so-called Wind Rose (Figure 1) is representing those two parameters graphically. The preferred wind direction has strong seasonal character. We continue to collect wind speed and direction data set for a longer period of time to better verify this finding.

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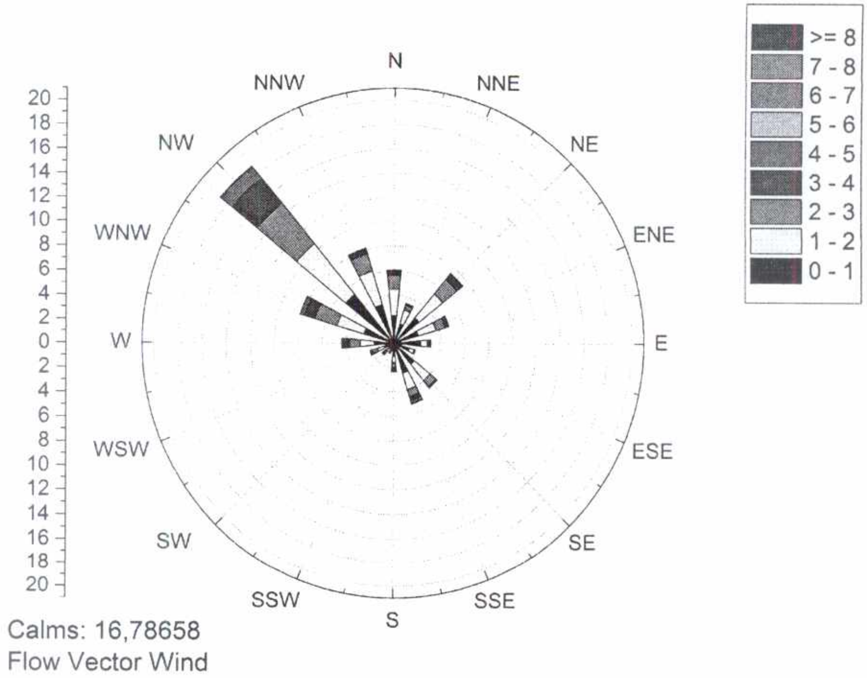

Figure 1: Wind rose for Autumn 2011. The bar on the left hand side shows the percentage of recorded data for period of one season. The box on the right hand side shows the wind speed in m/s.

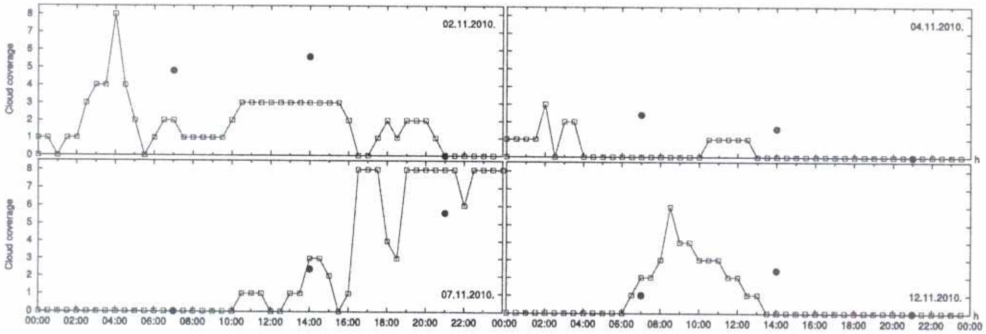

Figure 2: Cloud coverage over the Astronomical StationVidojevica (squares) and Meteorological Station Niš (full circles)

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OBSERVATIONAL ASTRONOMY AT PETNICA SCIENCE CENTER

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Abstract. During years 2012 and 2013, Petnica Science Center has been undergoing a thorough renovation and expansion. One of the new features will be new observational equipment intended for high-level educational work at the Department of astronomy. In this short paper we sum up main observational activities at Petnica Science Center, and discuss desired observational equipment.

1. INTRODUCTION

Petnica Science center (PSC) is an educational facility, intended primary for high-school students interested in science. Educational work is done through fifteen departments which cover most of modern science disciplines. The departments organize several seminars for students, on a yearly basis. The main goal of these events is to introduce participants to the modern science and to give them opportunity to: i) attend advanced lectures which are far beyond the scope of school curriculum; ii) do their own research in the desired field, while having equipment unavailable to their schools and collaborating with professional scientists.

The department of astronomy exists in Petnica Science center since its beginning. The majority of Serbian professional astronomers participated in the seminar as students, lecturers, research mentors, heads of the department, or sometimes, all four of those. Special attention is paid to the independent research projects of astronomy students. After their first year of attending the seminar, the whole second year is dedicated to students' research. They attend total of four seminars during the second year:

- Winter school: 4-5 day seminar with focus on modern research subjects in astronomy and astrophysics which are adaptable to the level of the advanced high school students. Professional astronomers are invited to give short lectures on their research topics and propose interesting research themes for students. If there are participants interested in the topic, the astronomer is appointed as a mentor, along with one or two junior associates which mediate and help the student with essential tools and the literature.
- Spring workshop: 3-4 day seminar where project proposals and preliminary investigations are performed with the mentors and junior associates. Also, small workshops on various topics are organized (e.g., numerical computing, astronomical image processing, data mining...).
- Summer school: two-week seminar, completely dedicated to the work on the project. Students are given complete freedom in managing their free time, they have access to observational and computing equipment under the supervision of junior associates and access to library and on-line resources.
- Autumn seminar: 4-5 day seminar where results of the research are transcribed, discussed and considered for the annual conference of Petnica students. Several short presentations of possible research topics for the following year are presented.

2. OBSERVATIONAL PROJECTS

Vast majority of research projects are either observational or computational with ratio which varies through years. Observational projects are chosen so that the observations can be done in relatively short period of time (week or two; in special cases, more observations during the year can be done). It is very important for the student to go, if possible, through all the stages of an observational research:

- Planning observing schedule and appropriate equipment (CCD camera, 35mm camera, adequate filters, etc..).
- Actually performing the observation, handling the telescope and the camera.
- Reducing observations.
- Discussing observations and inferring object physical properties.

During last ten years most projects were done on MEADE 178ED apochromat telescope mounted on Paramount ME robotic mount. SBIG ST-6 and ST-7 CCD camera were used, along with a filter wheel with UVBRcIc set of filters. Thanks to an excellent collaboration between PSC and the Astronomical Observatory from Belgrade (AOB), another CCD camera, SBIG ST-8 was sometimes available, and some observations were done at the telescopes belonging to AOB. Some of the research topics studied over the last ten years were:

- Multi-band photometry of close binary systems: Several short-period systems have been observed, complete image reduction and aperture photometry have been done, and astrophysical inversion has been performed with the help of researchers from AOB.

- Observation of exoplanet transits: Even with a small-aperture telescopes such as this one, transits of some exoplanets were detected from Petnica (most recently, TRES-3B) and rough estimation of planetary parameters was done.

- O-C analysis of binary systems with estimation of mass transfer and/or presence of the third body.

- Photometry of short period variable stars.

- Photometric observations of asteroids and determination of the asteroid shape from the light curve.

- Study of atmospheric extinction and light pollution over PSC.

Most of these research projects were presented at the annual conference of Petnica Science center students and later published in the proceedings of the conference. Conference follows the style of professional scientific conference, projects are presented as posters or oral presentations, papers are submitted for publishing afterwards and thoroughly reviewed prior to publishing. Proceedings of the conference as published by PSC, each year and sent to all collaborating institutions in the country and abroad. Papers are also available on-line (`http://prs.petnica.rs/eps`).

3. NEW EQUIPMENT

In years 2012/2013, PSC has undergone a major expansion, both in the terms of the infrastructure and in the terms of obtaining the new equipment. Having in mind interests of the astronomy students and desired expansion of possible research ideas, we plan to obtain the following equipment:

- A 60 cm reflector telescope with a robotic mount and an "out of the box" dome.

- One smaller (≈15 cm) telescope which can be mounted on the same robotic mount or de-attached and used with mobile robotic mount

- 2 CCD cameras intended mainly for photometric observations. We aim for fast, high-resolution (>2MP), high quantum efficiency cameras, with several sets of high quality wide- and narrow-band filters

- One high-quality digital camera (e.g. Cannon EOS 5 MK II) with appropriate adapters, intended for astrophotography.

Our main requirements for the telescope are wide field of view, ease of use and as low maintenance costs as possible. We plan to obtain CCD cameras and filter sets which are of good enough quality which will enable us to perform high-precision photometric observations so our telescope can be put at the disposal of researches from AOB and other professional astronomical institutions in the country or even from abroad. Even though observing conditions in Petnica are far from perfect, average seeing being around 2.5″, we see this as a possibility since Petnica is also relatively close to Belgrade (≈100 km). Also, we would like to extend research fields of our students to other topics such as: photometry of globular and open clusters, photometry of asteroids, exoplanet monitoring, etc. We plan to have at least some of the equipment ready for use in the summer of 2014. It is also our desire to collaborate more tightly with other departments from PSC so that some of our equipment, such as CCD cameras, can be put to use by students attending other seminars as well.

ACKNOWLEDGEMENTS. We would like to express our thanks to Astronomical observatory, Department of Astronomy of Belgrade Faculty of Mathematics, and to all other professional research institutions which were always ready to aid us and collaborate with our Department.

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PROXIMITY CALCULATION AND CHANGING OF DISTANCE FUNCTION

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Abstract. The paper discusses the analytical expression for the number and type of proximities of asteroids and changing of distance function for some characteristic simulations pairs of elliptical orbits. We show that the extreme values of critical points cannot be found in such groups.

Presentation link:
`http://belissima.aob.rs/Conf2012/Milisavljevic_2012.pdf`

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ASTRONOMY OLYMPIADS A CHALLENGE FOR FUTURE SCIENTISTS

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Abstract. Contests in astronomy for secondary school pupils, very often called "Astronomy Olympiads", have acquired a general recognition in many countries. They are regarded in various manners: as the best way to attract to science young talented people in general, the possibility to discriminate the most successful participants, who are then in position to be offered to become students of famous universities which is viewed as the beginning of a nice career, the possibility of affirmation of astronomy in secondary schools, the way to put together young amateur astronomers from various parts of the world, etc. On the other hand, there are some organisational problems which follow such events; they concern the relationship with the International Astronomical Union, outreach of the contests in different countries and many others. Serbia has been a member in the Astronomy-Olympiad Movement from 2002.

1. INTERNATIONAL CONTESTS IN ASTRONOMY TODAY

At present there exist two international contests in astronomy for teenage pupils. The word "international" should be understood as something covering the whole world (similarly to the case of International Astronomical Union).

The contest known as "International Astronomy Olympiad" (IAO) is older, it took place for the first time in 1996. The other contest, "International Olympiad on Astronomy and Astrophysics" (IOAA) appeared in 2007. Both take place once a year. Due to this in 2012 we had the 17th IAO and VI IOAA.

The two contests have much in common which is not surprising. There are three contest rounds: theoretical, practical (also known as data analysis) and observational. In both cases in the framework of the theoretical round a contestant is required to solve a set of problems. The problems are mostly based on the knowledge of astronomical (physical) background rather than on an advanced mathematics. A special property of IOAA is the existence of two sorts of problems - "short" and "long" ones. The short problems, clearly, can be solved within a shorter time interval, but they are much more numerous than the long ones (usually 15 and 2, respectively), therefore their weight (number of points) is smaller. A special property of IAO is the lower age limit (14) and, consequently, the contestants are divided into two age categories – juniors and seniors; to be a junior contestant one may be also 15, but provided that this is the first participation. These two age groups do not have the same tasks to solve in the framework of the three rounds. The other two rounds (data analysis and observational) in the two contests are rather similar. Data analysis includes both the treatment of observational data, as well as the data taken from a catalogue. In both cases the use of computers is not foreseen (just as in the case of theory contestants are allowed to use only pocket calculators). The observational round is foreseen to take place, whenever possible, under open sky. For this purpose an additional night is always borne in mind for the case that during the first night the weather conditions are not favourable. If even during the second night the conditions are also unfavourable, then the alternative possibility is realised, the observational round takes place "under a roof" (often in a planetarium). In both cases (IAO and IOAA) the observational tasks have a short duration and a contestant is expected to know the sky (constellations, bright stars, famous objects) very well. In other words the observational round does not resemble too much the practice of astronomical observations, especially not as this is the case nowadays; more precisely almost no measuring and also no error estimation.

It is clear that almost in all of participating countries internal contests take place. They can have several levels (subnational levels and the national one). The evidence shows that in this matter there are great differences from country to country.

Finally, there are also contests in astronomy which cover a sufficiently large group of countries where these countries have something in common; examples are Asian-Pacific Astronomy Olympiad (APAO) and Olimpiada Latinoamericana de Astronomia y Astronautica (OLAA). In the first of these cases the gathering factor has a geographical nature, but in the second one there is also the language factor (Spanish and Portuguese). In general language is an important factor because in the case of a multi-language contest the problems and tasks are originally in the official language (languages) of the contest, to be translated then into national languages by team leaders. Therefore, existence of contests where the official language (languages) is (are) close to all participants, practically with no need for translation, is not surprising. The development of IAO may be a good example, it was preceded by a contest which covered the countries from the Russian speaking area, so today IAO has two official languages: English and Russian. On the other hand, being founded as a purely international contest IOAA has only one official language – English.

2. OBJECTIVES OF A CONTEST IN ASTRONOMY

The objectives of a contest in astronomy for secondary-school pupils may be divers. They certainly depend on particular conditions in a country. First of all there are countries with a rich tradition for contests in astronomy. Examples are the Russian Federation (also all other countries of the former Soviet Union) and Poland. On the other hand, the increasing interest in such contests in recent times in Asian countries is noticeable. However, the experience of both IAO and IOAA indicates the weak interest of countries with highly developed professional astronomy (absence of the USA, the UK, France, Germany, Australia, Spain).

Among the objectives one can meet identification of talented students regarded above all as future university students with astronomy (astrophysics) as the main subject (e. g. Eskin et al. 2012). In general very successful contestants view their success as a way to "pave their roads" towards enrolling prestigious universities. It is well known that some former contestants, who had achieved excellent results at IAO or IOAA, later became students at universities like Cambridge, Harvard, etc. This is also the case with international contests in mathematics, physics, chemistry and so on. In the case of astronomy contests, for reasons already stated above, one can find out that these contestants were from countries situated in middle/eastern Europe or Asia, as a rule, not too rich countries and almost without famous universities. Therefore, an entrance ticket to a prestigious university, including a scholarship, is, of course, something very valuable.

When objectives are the topic, one should not, certainly, forget the promotion and dissemination of astronomy. According to the existing evidence, astronomy is hardly present as a special subject in the under-university level of education. Also ordinary people are often ignorant as to understanding of celestial phenomena. Therefore, it is very important to involve as many pupils as possible in a kind of astronomy teaching. The participation in a national (international) contest may serve as an additional stimulus for attending such kind of astronomy teaching. In particular, one bears in mind the so-called extra-teaching, i.e., to meet the necessities of more interested pupils who would get an opportunity to learn more than what is foreseen in the school syllabus.

Another objective of contests in astronomy may concern the situation with developing countries. Universities and colleges are indispensable as sources and places where sophisticated knowledge is acquired. They are in some way connected to the teaching process on lower education levels. However, the distribution of prestigious universities (world map) is far from uniform. Countries, usually referred to as developing, have in general problems with high-quality education. Therefore, the case of an international contest putting together pupils from all over the world can be very useful. In this way educators from developing countries will be able to gather a large amount of valuable information, which can have a positive impact on the improvement of the teaching process in general and, especially in the case of such an extraordinary science as astronomy is. It should be said that the International Astronomical Union has recognised this objective as very important.

Whenever astronomy is the topic, one should not forget amateur astronomers. Usually they are organised within proper societies. With regard to the well-known fact that the enthusiasm decreases with age most of the members of such societies are rather young persons, secondary-school pupils. Many of them try their chance within a contest. In this way an international contest in astronomy offers the possibility of putting together young amateur astronomers from many mutually distant countries at one place, which helps them exchange the experience.

3. CONTESTS IN ASTRONOMY VERSUS ORGANISATIONAL PROBLEMS

As said above, there exist two international (tending to cover the whole planet) contests in astronomy. At first glance this circumstance may seem favourable because of a "sound" competition. However, in a science like astronomy this may have not good consequences. The attending countries differ in their approaches. In some of them the general policy seems to be like "the more contests, the better", so they send regularly their teams (mostly not the same pupils) to both international contests. On the other hand, there are countries which, though very interested in astronomy contests in general, cannot, for various reasons, send teams regularly to both contests.

Finally, the attitude of some countries can be described as reluctant because, though known to have contests in astronomy inside themselves, they still have not sent a team to either of the two contests. The reason of this reluctance may be just that they have not been able to choose between the two options, leaving to the future to identify the decisive advantage of one of the two contests present now. The attitude of the International Astronomical Union (Commission 46) is also interesting; though through a letter IOAA was recognised, no official of Commisssion 46 has ever come to greet personally an IOAA contest. On the other hand, some IOAA officials find such an attitude favourable because of the worry that a closer relationship with IAU could result in a limitation of IOAA independence. Certainly, all of this is followed by financial problems. Perhaps, among them one should look for the reason why some countries attend regularly contests covering parts of the world (already mentioned Latin America, Asia and Pacific), but have never sent a team to either of the two international contests. If a brief statistics including countries which have attended contests in astronomy sufficiently regularly (say more than once, any of the four mentioned above) were made, a set of 38 countries could be formed with the following geographic distribution: Latin America 8, Europe 18, Asia 12. A number approaching 40 is obtained, it is curious to note that the host country of the next IOAA in 2013, Greece, has made its plan, just based on the contingency of 40 participating countries!

4. THE ROLE OF CONTESTS IN ASTRONOMY IN SERBIA

For the first time Serbia attended an international contest in astronomy in 2002. It was the seventh IAO. This required the foundation of a national contest in astronomy (National Astronomy Olympiad) in Serbia. The Serbian National Contest serves as a selection of contestants for international contests. From 2007 the National Contest has been regularly preceded by a regional contest (contests). It also has a selective role since contestants having too bad results are not allowed to take part in the National Contest. All these contests have been characterised by a strong domination of pupils from the Mathematical High School in Belgrade. Pupils from other schools both from Belgrade and from other parts of Serbia have rarely been among the participants. Therefore, it is clear why regional contests for regions beyond Belgrade have not been regular. A good illustration is the fact that among the pupils who have taken part in international contests, there has been no single one from any other school different from the Mathematical High School in Belgrade! Due to this circumstance the number of contestants on the first (regional) level has rarely exceeded 20, which is very small when compared to the analogous data for other countries, but, nevertheless, contestants from Serbia have been very successful at the international contests; by the way they have participated in IAO nine times and four times in IOAA and have brought home more than thirty prizes!

5. INSTEAD OF A CONCLUSION

What can the near future bring? The present author hopes that the situation with the two international contests will become clearer. Also contests covering parts of the world (continents, subcontinents) and groups of countries with similarities in culture and language, in principle, should not appear as competitive, or excluding, to a purely international contest, but the money problem can be a severe hindrance, compelling some countries to choose between the two kinds of contest.

As for Serbia, it remains to hope that in the future secondary-school pupils in general will have better opportunities to learn more about astronomy and celestial phenomena making it possible in this way that astronomical contests in Serbia are no longer the privilege of the Mathematical High School in Belgrade. Of course, the rich tradition of successful participation in international contests is expected to be continued also in the future.

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MODELLING OF RESONANCE LINES IN INHOMOGENEOUS HOT STAR WINDS

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Abstract. The instability of wind radiative driving may cause the occurrence of wind shocks and spatial wind density and velocity structures. Observational evidence suggests that clumpy structures are a common property and a universal phenomenon of all massive, hot star winds. The structured stellar winds are essentially three-dimensional (3-D), and the full description requires the 3-D radiative transfer. Calculations using our own full 3-D Monte Carlo radiative transfer code for inhomogeneous expanding stellar winds are presented. We show how different model parameters influence resonance line formation. By modelling ultraviolet resonance lines, we demonstrate how wind inhomogeneities influence line profiles.

1. INTRODUCTION

In the course of past few decades, there has been growing evidence that the stellar winds are not smooth, as opposed to what has been assumed by most models of spherically symmetric line driven winds (see proceedings Hamann et al. 2008). Detailed theoretical studies showed that the line-driven winds are intrinsically unstable (Lucy & White 1980). Theoretical evidence of clumping is based on numerical simulations of radiatively line driven stellar winds. It is known that the instability of wind radiative driving may cause the occurrence of wind shocks and spatial wind density structures called clumps. Theoretical predictions are supported by direct observational evidence of clumping (e.g. Eversberg et al. 1998).

2. WIND MODEL

Our wind model (see Fig. 1) consists of a smooth region (i.e. without clumps) $r_{\min} < r < r_{\mathrm{cl}}$ (the inner wind radius is taken to be the stellar radius, $r_{\min} = R_*$) and a clumped region $r_{\mathrm{cl}} < r < r_{\max}$. The latter region has two components, namely the clumps and the inter-clump medium (ICM). The underlying wind velocity field is assumed to obey the β-law,

$$v_\beta(r) = v_\infty \left(1 - \frac{b}{r}\right)^\beta , \tag{1}$$

and the wind line opacity $\chi(r)$ is taken into account in a parametric way following Hamann (1980),

$$\chi(r) = \frac{\chi_0}{r^2 v_\beta(r)/v_D}\, q(r)\, \phi_x \tag{2}$$

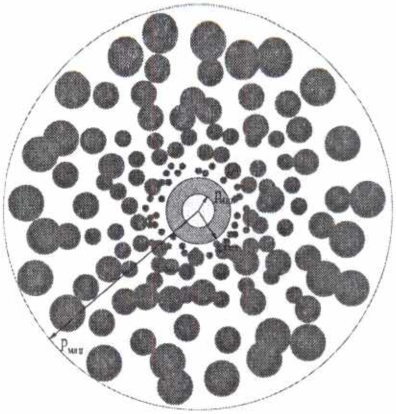

Figure 1: A schematic view on a wind model. The circle in a center represents the star, the annulus around it is a smooth wind region, and the circles around it represent clumps.

where $\phi_x = (1/\sqrt{\pi})\, e^{-x^2}$ is the Doppler line profile, χ_0 is the opacity parameter, x is the dimensionless frequency, and $q(r)$ is the ionization fraction, usually taken to be equal to 1 (constant ionization condition).

Our model can account for macroclumping, i.e. clumps in the wind can be optically thick. Optically thin clumps can be treated as well. This differs from usual treatment of clumping in NLTE wind codes, which can handle only optically thin clumps. Clumps are statistically distributed with average separation $L(r)$ and are assumed to be spherical with the radius $l(r)$. The density inside clumps $\rho_{\rm cl}(r) = D\,\rho_{\rm sw}(r)$, where $\rho_{\rm sw}(r)$ is the density of a smooth wind, and $D \geq 1$ is the clumping factor. Number density of clumps $n_{\rm cl} \propto \left(r^2 v_r\right)^{-1}$, which means that the average clump separation $L = n_{\rm cl}^{-1/3}$. Both clump distribution and clump radius are characterized by the clump separation parameter L_0,

$$L(r) = L_0 \sqrt[3]{r^2\,\frac{v_r}{v_\infty}}, \qquad l(r) = L_0 \sqrt[3]{\frac{3}{4\pi D}\, r^2\, \frac{v_r}{v_\infty}}. \tag{3}$$

The density of ICM, $\rho_{\rm ic} = d\rho_{\rm sw}$, where $0 \leq d < 1$ is the ICM density factor.

Using these free parameters (D, L_0, and d) we create a clump distribution. The distance of the i-th clump ($i = 1, \ldots, N_{\rm cl}$, $N_{\rm cl}$ is the total number of clumps) from the stellar center $r_i = (r_{\max} - r_{\rm cl})\xi_i + r_{\rm cl}$, where $0 < \xi_i \leq 1$ is a random number, which is chosen to obey the probability density distribution function $1/v_\beta(r)$. For the case of "vorosity" (inhomogeneities in the velocity field), velocity inside clumps is expressed as

$$v(r) = v_\beta(r) + v_{\rm dis}\,\frac{r - r_i^{\rm c}}{l_i}, \tag{4}$$

where $v_{\rm dis} = m\, v_\beta(r)$, $0 < m \leq 1$, and $r_i^{\rm c}$ is the position of the i-th clump's center.

We used several additional simplifying assumptions in our model. We assumed that radiation entering the wind at the lower boundary is free of lines and that there is no limb darkening. The lines are assumed to be pure scattering ones with a Doppler profile, and with complete redistribution.

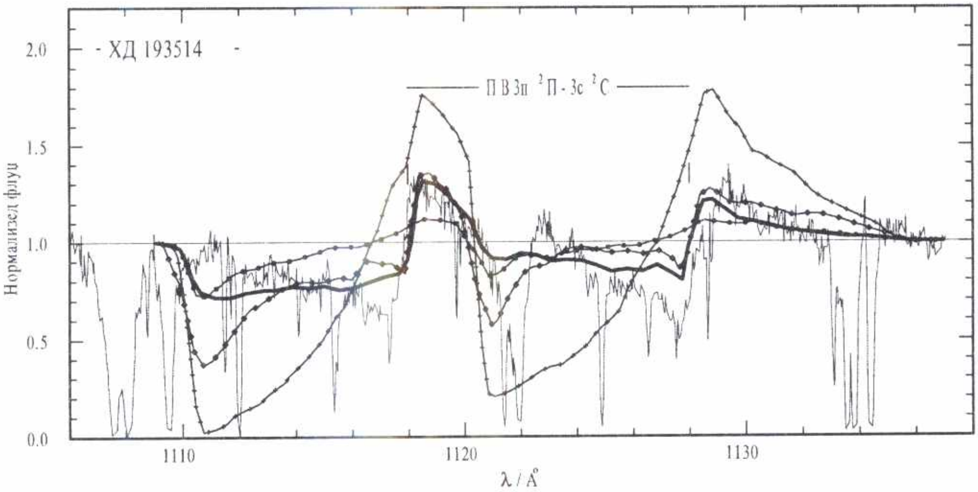

Figure 2: Comparison of line profiles calculated using different wind models with the observed spectrum of HD 193514 observed by FUSE (the thin full line). Models were calculated for $v_\infty = 2200\,\mathrm{km\,s^{-1}}$, $\chi_0 = 462.58$, and $v_D = 20\,\mathrm{km\,s^{-1}}$. The smooth (unclumped) wind model is shown by the full line with crosses. Clumped models are calculated for $L_0 = 0.5$. The full line with circles corresponds to the clumped wind model with the clumping factor $D = 10$, void ICM, and monotonic velocity. The full line with squares is the clumped wind with $D = 10$, non-void ICM ($d = 0.05$), and $v_{\rm dis}/v_\beta = 0.1$. The thick full line is the best fit with $D = 400$, $d = 0.05$ and $v_{\rm dis}/v_\beta = 0.1$.

3. MONTE CARLO RADIATIVE TRANSFER

The radiative transfer is solved using the Monte Carlo method by following the path of individual photon packets (hereafter photons). Each photon is sent from the surface of the star, both its frequency and initial direction are randomly determined. Then the optical path, which it is allowed to travel is determined also randomly. Then the photon starts its travel and the passed optical distance is accumulated by integrating the opacity along its path. Once the integrated optical path reaches the randomly preselected optical depth, it defines the place of interaction and scattering happens there. After scattering, new photon direction is randomly determined and the process is repeated. After the photon leaves the star, its frequency is stored into a predefined frequency bin and a new photon is sent from the surface. After all photons are sent, emergent flux is determined for all bins. Our method was described in detail in Šurlan (2012).

4. COMPARISON WITH OBSERVATION

Here we applied our code to fit the P V resonance doublet of HD 193514 observed by FUSE (thin line in Fig. 2). As the terminal velocity of HD 193514 we adopt $v_\infty = 2200\,\mathrm{km\,s^{-1}}$, and the value of $\beta = 0.7$. The synthetic spectra of the smooth and clumped wind models are calculated. The model parameters are chosen to fit the observed spectrum best. It can be seen that the predicted unclumped (smooth) P-Cygni profile (full line with crosses) of P V is much stronger than the observed one (thin full line). However, the synthetic spectrum for the clumped model with appropriate clumping parameters (thick full line) fits the strength of the observed line very well. Therefore, using the unclumped model can lead to underestimating the empirical mass-loss rates. These results are consistent with Oskinova et al. (2007), Sundqvist et al. (2010, 2011), and Šurlan et al. (2012a,b).

5. CONCLUSIONS

The influence of macroclumping on line profiles is striking. When macroclumping is taken into account line strength becomes significantly weaker. For a given clumping factor D, the key model parameter L_0 further affects the effective opacity and, consequently, the mass-loss rate $\dot{M}$. The line saturation is strongly affected by the inter-clump medium. Our 3-D model confirms that any mass-loss diagnostics which do not account for wind clumping must underestimate the actual mass-loss rate $\dot{M}$.

ACKNOWLEDGEMENTS. This work was supported by grants GA ČR 205/08/0003 and GA UK 424411.

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Publ. Astron. Obs. Belgrade No. 92 (2013), 201 - 204 *Poster*

DETECTION OF A 1.59H PERIOD IN THE B SUPERGIANT STAR HD 202850

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Abstract. Photospheric lines of B-type supergiants show variability in their profile shapes. In addition, their widths are much larger than purely due to stellar rotation. This excess broadening is often referred to as macroturbulence. Both effects have been linked to stellar oscillations, however B supergiants have not been systematically searched yet for the presence of especially short-term variability caused by stellar pulsations. We obtained four time-series of high-quality optical spectra for the Galactic B supergiant HD 202850 with Ondřejov 2-m telescope. The spectral coverage of about 500 Å around H_α encompasses the Si II (6347, 6371 Å) and He I (6678 Å) photospheric lines. Their time-series display a simultaneous, periodic variability in their profile shapes. Proper analysis using the moment method revealed a period of 1.59 hours in all three lines. This period is found to be stable with time over the observed span of 19 months. This period is much shorter than the rotation period of the star and might be ascribed to stellar oscillations. Since the star seems to fall outside the currently known pulsational instability domains, the nature of the discovered oscillation remains unclear.

1. INTRODUCTION

Massive stars are very important for stellar and galactic evolution. As they end their lives in supernova explosions, they enrich the interstellar medium with heavier elements and deposit large amounts of energy and momentum into their surroundings. B supergiants are massive stars. It has been reported that they show both photometric and spectroscopic variability (Lefever et al. 2007, Markova & Puls 2008). Their lines are also much wider than expected from pure stellar rotation, and this phenomenon is usually called macroturbulence (Simón-Díaz et al. 2010). Both macroturbulence and line profile variability (LPV) had been linked to stellar pulsations. So, together with the LPV the presence of macroturbulence in a star points towards stellar pulsation. Pulsating stars are restricted to several regions of the Hertzsprung-Russell diagram; these regions are called instability domains. Recently, a new instability domain in the region of B-type supergiants has been found (Saio et al. 2006).
Here we report on the discovery of a short-term variability in the late-type B supergiant HD 202850 (= σ Cyg). This star has been classified as B9 Iab. It is located in

the OB association Cyg OB 4 at a distance of ≈ 1kpc. Its stellar parameters are given in Table 1. With these parameters, it falls outside the instability domain for evolved massive stars calculated by Siao at al. (2011).

Table 1: Stellar parameters for HD 202850. References: (1) Markova & Puls (2008), (2) this work.

T_{eff}	$\log L/L_{\odot}$	$\log g$	R_*	M	$v \sin i$	v_{macro}	Reference
[K]		[cgs]	$[R_{\odot}]$	$[M_{\odot}]$	[km/s]	[km/s]	
11000	4.59	1.87	54	8^{+4}_{-3}	33 ± 2	33 ± 2	(1)
					23 ± 1	33 ± 7	(2)

2. OBSERVATION

We observed HD202850 on 2010 September 6, 11, and 12 and on 2012 April 30 (see Table 2), using the Coudé spectrograph attached to the 2-m telescope at Ondřejov Observatory (Šlechta & Škoda 2002). We used the 830.77 lines mm^{-1} grating with a SITe 2030 × 800 CCD that delivered a spectral resolution of $R \approx 13000$ in the H_{α} region with a wavelength coverage from 6253 Å to 6764 Å. For wavelength calibration, a comparison spectrum of a ThAr lamp was taken immediately after each exposure. The stability of the wavelength scale was verified by measuring the wavelength centroids of OI sky lines. The velocity scale remained stable within $1\,\mathrm{km\,s^{-1}}$.

The data were reduced and heliocentric velocity corrected using standard IRAF tasks. On each night we also observed a rapidly rotating star (HR7880, Regulus) to perform the telluric correction. Final ranges in signal-to-noise ratios (SNR) are 250-500, and the data with the highest quality were those obtained on 2010 September 12.

Table 2: Observing journals.

HJD	t_{exp}	HJD	t_{exp}		t_{exp}	HJD	t_{exp}	HJD	t_{exp}		t_{exp}
(2455466+)	[s]	(2455466+)	[s]	HJD(2455466+)	[s]	(2455466+)	[s]	(2455466+)	[s]	HJD(2455466+)	[s]
0.37462	600	0.47388	600	5.53004	600	6.38528	300	582.50304	300	582.56252	300
0.38362	600	0.48296	600	6.32982	250	6.39076	300	582.50843	300	582.56794	300
0.39268	600	0.49201	600	6.33502	300	6.39631	300	582.51384	300	582.57336	300
0.40173	600	0.50103	600	6.34064	300	6.40179	300	582.51925	300	582.57877	300
0.41073	600	0.51002	600	6.3461	300	6.40736	300	582.52465	300	582.58416	300
0.41974	600	5.47616	600	6.35213	300	6.41293	300	582.53005	300	582.58957	300
0.42877	600	5.48516	600	6.35767	300	6.4185	300	582.53547	300	582.59496	300
0.43781	600	5.49411	600	6.36317	300	6.4241	300	582.54087	300	582.60036	300
0.44683	600	5.50312	600	6.36868	300	6.42976	300	582.54629	300	582.60576	300
0.45582	600	5.51209	600	6.37426	300	582.49219	300	582.5517	300	582.61125	300
0.46486	600	5.52107	600	6.37977	300	582.49762	300	582.5571	300		

3. RESULTS

3. 1. MACROTURBULENCE

We applied two methods to the data to confirm the pulsation period. To prove the presence of macroturbulence we measured half width half maximum (HWHM) values. Then we calculated the projected rotational velocity ($v \sin i$) with the Fourier method and, using these $v \sin i$ values, we calculated the expected HWHM values. Those were compared to the measured ones. The large deviation confirms the presence of macroturbulence. Our values obtained for both $v \sin i$ and v_{macro} are listed in Table 1 together with those of Markova & Puls (2008).

3. 2. LINE PROFILE VARIABILITY

The time-series of the line profiles are shown in Figure 1. Visual inspection shows already a shift in central wavelength coupled with a temporal progression of asymmetries. These are typical characteristics for pulsations. To confirm the presence of pulsations, we apply the moment method. Each spectral line can be fully characterised by its line profile moments (Aerts et al. 2010). Each moment has a physical meaning. The zeroth moment represents equivalent width, the first moment ($< v^1 >$) represents radial velocity, the second moment ($< v^2 >$) gives a measure of the line width, and the third moment ($< v^3 >$) gives a measure of the line asymmetry. This method is very efficient in proving the pulsation modes, but it requires a high SNR and a medium to high spectral resolution. The second moment especially suffers from the noise.

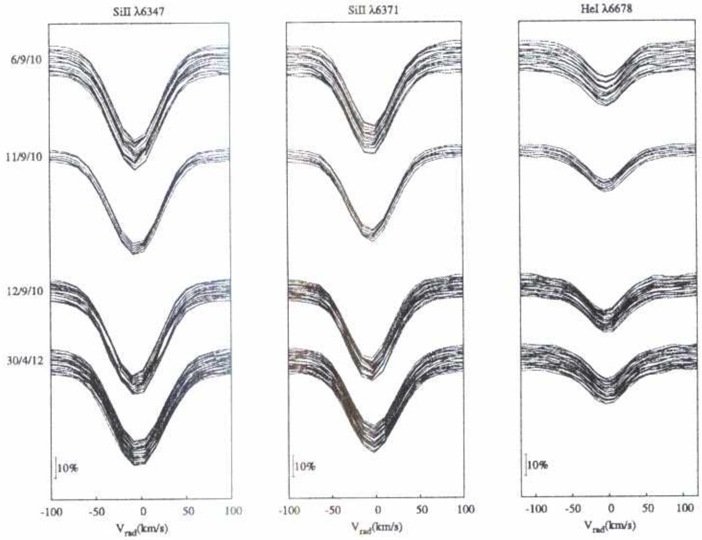

Figure 1: Time-series of line profiles of three photospheric lines we analysed. Time increases from top to bottom.

The results from our moment computations are shown in Figure 2. Obviously, the first and third moments vary in phase. To find the period to which the moments are phased, we applied two independent methods: a Fourier transformation of the moments and a simple sine curve fit. Both delivered the same period of $P = 1.59 \pm 0.01\,\mathrm{h}$ for all three lines (see Kraus et al. 2012). The second moment is phased as well, but it was too noisy to recover any period.

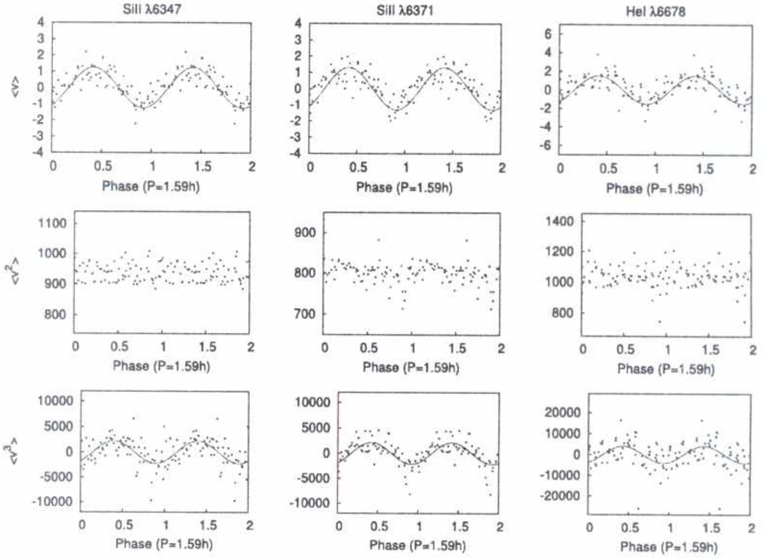

Figure 2: Calculated moments for all three photospheric lines plotted versus phase.

4. CONCLUSION

We observed periodic changes in the first and third moments of photospheric lines in the B supergiant HD 202850. The discovered 1.59 h period is stable over the period of 2 years. Three photospheric lines of two different elements change in the same manner and in the same phase. Together with the macroturbulence in these lines, this leads to the conclusion that there is a stable pulsation with 1.59 h period present in this star. It is not possible to determine the type of the pulsation because the second moment is badly affected by the noise. Also the nature of the variability remains unclear, because this star is not in a region of any known instability.

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ASTRONOMY IN THE MEDIA IN SERBIA

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Abstract. A notice of astronomy related media contents is given. One finds the contemporary media to have a significant share in the popularization of astronomy, which is primarily directed to a younger population. Also, the author wants to indicate some incorrectness in dissemination and popularization of scientific facts from the history of astronomical science.

1. INTRODUCTION

The media expansion has emphasized their important role in the public outreach. In a number of TV shows and columns in various media (newspapers, radio and TV programs) astronomical topics have been the subject, which has contributed significantly to popularizing astronomy as a science.

2. MEDIA AND ASTRONOMY

Texts with astronomical contents can be found in almost all news media (usually in Blic, Politika, Večernje novosti, Danas, Dnevnik, Glas javnosti, Press, ALO, 24 Sata, etc.), and also in the programs of the radio and TV stations (RTS (Serbian Broadcasting Corporation), RTV Studio B, RTV, TV B92, Prva srpska televizija, TV Pink, Happy TV, TV Metropolis, TV Enter, Art, etc.), as well as local radio and TV stations throughout Serbia. Occasionally, contributions and interviews concerning sensational astronomical events and phenomena, causing particular interest in the public such as the impact of comet Shoemaker-Levy on Jupiter (1994), Venus transit across the Sun disc, recent research on black holes and quasars, etc., as well as astrobiology and modern cosmological theories have appeared.

At the RTS (Serbian Broadcasting Corporation), within the Science Editorial, which was officially formed in 1970, there are also programs of serial character, in which the relevant events and discoveries from the world of astronomy and astrophysics are presented (Context 21, Café Scientifique, One Step to Science, Modern World, Encyclopedia, Horizons, 30 Days in Science). There were also a few memorable shows in the past few years: Café Scientifique – Dark Side of the Universe, 2008; Café Scientifique – CERN's Journey to the Center of Matter, 2010; World Challenge – CERN, 2010; Café Scientifique – Hazards of the Solar System, 2012; Café Scientifique – Black Hole, 2012. Also, a few years ago (2006) at the TV Studio B an interesting series on cosmology was presented.

The School Desk of RTS has also broadcast a program with astronomical contents directed first of all to the population of pupils. The serial program "Café Scientifique" conceived so to have an interactive character, where young participants ask questions interested to them and concerning the topic of the show. There has been some magazines for young population with pages exclusively devoted to astronomy (Fig. 1).

Кекец 1. 9. 1960.

Писао Д. Л. Бурковић

ЗА АСТРОНОМЕ

Figure 1: Astronomy in the magazine "Kekec" for the youngest from 1960.

Васиона изнад Звездаре

Курс за почетнике

Астрономија поново у моди

О свемиру у Планетаријуму

Почиње топлија и дужа полов

АСТРОНОМСКИ ПЕТАК У ВРШЦУ

BEOGRAD

li svet u astronomij

У наредних неколико месеци

Небеске занимљивости

Figure 2: Collage of the newspaper articles on astronomy.

Astronomy popularization among pupils has contributed to organizing contests in this discipline on equal levels with contests in mathematics and physics.

Staff members of the Belgrade Astronomical Observatory, as well as those from the Public Observatory, have mostly cooperated with the media, presenting current issues and interesting information (contents) on astronomy. Some of them have had author shows on radio and TV. The Pubic Observatory of Belgrade, where Astronomical Society "Rudjer Bošković" works, regularly reports the media on its activities, on free courses for citizens, on Belgrade Astronomical Weekend, Summer Schools of Astronomy and Summer Astronomical Meeting, various lectures in the Planetaria, the beginning of the seasons, and the many other events related to astronomy (Fig. 2). A complementary role in popularizing astronomical contents through the media have the Association of Astronomical Societies and Astronomical Sections of Vojvodina and the amateur astronomical associations of Serbia, which were founded in 2010 (Atanacković, 2012).

Modern media present the contents, also, on their websites, so that articles and news in astronomy can be reached via the Internet. Note that a large number of articles with the astronomical contents can be found in the Science section of www.b92.net site, since 2005. Also, on many other web pages, especially on the sites of amateur astronomical societies (their number in Serbia is presently 20) there is information, which contributes to the popularization of astronomy and related sciences among the younger population.

The author also wants to indicate a case of incorrect dissemination and popularization of results from astronomy and related sciences in the media, where there is an attempt to present Milutin Milanković as the sole author of the calendar, although he only changed the intercalation rule in the calendar of Maksim Trpković, which originates from the basis of this calendar (see: Milanković, 1923; Simovljević, 1996; Kečkić, 2001).

3. CONCLUSION

After examining the current material, we can say that the presence of astronomical contents in media is satisfactory. Modern media has an essential influence on informing and educating the general population, and greatly contribute to the dissemination of astronomy. Therefore, it is necessary that information is spread with responsibility following the truth and based on scientific arguments.

ACKNOWLEDGEMENTS. The author would like to thank the Science Editorial and School Desk of RTS (Serbian Broadcasting Corporation) for the obtained data of the relevant contributions, as well as the AS "Rudjer Bošković" and its secretary Mr. Milan Jeličić for obtaining access to the work diary and copies of newspaper articles on astronomy. This research has been supported by the Ministry of Education, Science and Technological Development of the Republic of Serbia through the Project No. 179048.

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Publ. Astron. Obs. Belgrade No. 92 (2013), 209 - 212 *Conference Program*

Celebrating the 125th Anniversary of the Astronomical Observatory of Belgrade
International BELISSIMA Conference

FUTURE SCIENCE WITH METRE-CLASS TELESCOPES

18-21 September 2012 -- Belgrade, Serbia
Tulip Inn Putnik Belgrade Hotel
http://futurescience.aob.rs

CONFERENCE PROGRAM

Invited talks are in *italics*.

Monday, 17th September 2012

16:30 – 19:30 Registration desk open at Tulip Inn Putnik Belgrade Hotel

Tuesday, 18th September 2012

09:00-09:30	Registration desk open at Tulip Inn Putnik Belgrade Hotel	
09:30-10:00	Opening/Z. Knežević	Welcome message
10:00-10:15	S. Samurović	The Belissima project

MAIN THEME: METRE-CLASS TELESCOPES AND INSTRUMENTS

10:15-10:55	*A.N. Ramaprakash*	*Can small beat the big?*
10:55-11:25	Coffee break	
11:25-11:45	M. Weber	The STELLA robotic observatory on Tenerife
11:45-12:05	L. Leedjärv	Small is beautiful - experience and plans of the Tartu Observatory
12:05-12:25	V. Perdelwitz	Astronomical Fourier Transform Spectroscopy at the Hamburg Observatory
12:25-12:45	M. Bogosavljević	Vidojevica status report 2012
12:45-14:30	Lunch break	
14:30-15:10	*F. Grundahl*	*SONG is starting to sing*
15:10-15:30	I. Vince	An Echelle Spectrograph for Milanković Telescope
15:30-15:50	G. Szabo	Follow-up lucky imaging observations of Kepler targets
15:50-16:20	Coffee break	
16:20-17:00	*T. Bonev*	*New modes of observation at the 2-m telescope of Rozhen observatory: parameters of the instruments and first results*
17:00-17:40	(N.N.)	Panel Discussion: Telescopes and Instrumentation

Wednesday, 19th September 2012

MAIN THEME: SCIENCE WITH METRE-CLASS TELESCOPES (I)

09:00-09:15	Start of day 2	
09:15-09:55	*P. Pravec*	*Asteroid properties from photometric observations: Constraining non-gravitational processes in asteroids*
09:55-10:15	T. Pribulla	Eclipsing binaries - precise clocks to discover exoplanets
10:15-11:05	Coffee break	
11:05-11:45	*A. Milani*	*Surveys with innovative one-meter telescopes: asteroids,debris...*
11:45-12:05	A. Zakharov	Exoplanet searches with gravitational microlensing
12:05-12:25	L. Eyer	GAIA follow-up (via Skype)
12:25-13:00	(N.N.)	Panel Discussion: Science (part I)
13:00-14:30	Lunch break	

MAIN THEME: SCIENCE WITH METRE-CLASS TELESCOPES (II)

14:30-15:10	*L. Kiss*	*Affordable Doppler velocities to 50 m/s with sub-meter telescopes*
15:10-15:30	R. Pavlović	From the first CCD measurements of double stars at Vidojevica towards speckleinterferometry
15:30-15:50	D. Urošević	Optical detection of the emission nebulae in nearby galaxies
15:50-16:10	T. Petrushevska	Search for lensed supernovae by massive galaxy clusters with the 2.5 m Nordic Optical Telescope
16:10-16:40	Coffee break	
16:40-17:20	*P. Heinzel*	*Observations and modeling of stellar flares*
17:20-18:00	(N.N.)	Panel discussion: Science (part II)

20:00-22:00 Conference dinner at SOKOJ restaurant

Thursday, 20th September 2012

MAIN THEME: NETWORED TELESCOPES, NETWORKED SCIENCE

09:00-09:15	Start of day 3	
09:15-09:55	*T. Brown*	*LCOGT: A World-wide Network of Robotic Telescopes*
09:55-10:15	D. Denisenko	First Results and Perspectives of the MASTER Robotic Telescopes Network
10:15-10:35	Z. Ioannou	The 2012 AE Aqr Multiwavelegth Campaign
10:35-11:05	Coffee break	
11:05-11:45	*G. Djorgovski*	*Exploration of the Time Domain*
11:45-12:05	N. Giakoumidis	Simulating a Global Robotic Telescope Network
12:05-12:40	(N.N.)	Panel Discussion: Networked telescopes, networked science
12:40-14:30	Lunch break	

MAIN THEME: EDUCATION AND PUBLIC OUTREACH

14:30-15:10	*O. Atanacković*	*Astronomy education and popularization in Serbia*
15:10-15:50	(N.N.)	Panel Discussion: Education, public outreach and popularization of astronomy
15:50-16:20	Coffee break	
16:20-17:00	*G. Longo*	*Astroinformatics, virtual observatory and web 2.0*
17:00-17:40	(N.N.)	Panel Discussion - Astroinformatics

Friday, 21st September 2012

MAIN THEME: CELEBRATING THE 125-YEARS OF THE ASTRONOMICAL OBSERVATORY

09:15-09:55	*P. Battinelli*	*Asymptotic Giant Branch stars*
09:55-10:10	D. Ilić	Long term optical monitoring of AGN
10:10-10:25	E. Bon	First Spectroscopically resolved orbit of a supermassive black hole binary
10:25-10:40	O. Latković	Modeling of Interacting Binary Systems
10:40-10:55	O. Vince	The DWARF project: Vidojevica
10:55-11:25	Coffee break	
11:25-12:05	*J. Kubat*	*Mass-loss rates of hot stars*
12:05-12:45	(N.N.)	Panel Discussion "Future Science"
12:45-13:15	(N.N.)	Conference Summary and closing remarks
17:00 – 19:00		Visit to Astronomical Observatory Belgrade

POSTERS (Tue – Fri)

J. Aleksić	Popularization of astronomy through robotic telescopes and virtual observatories
V. Čadež	Peculiarities of ionospheric response to Solar eruptive events
G. Damljanović	Possibilities of ICRF2 ERS Observations using ASV 60cm telescope
I. Di Varano	Long time series observations from Antarctica with ICE-T
N. Giakoumidis	Simulating a Global Robotic Telescope Network
M. Jovanović	PARSES/FERRE pipeline for determining the stellar parameters
S. Kohl	Lucky imaging at the Oskar-L
P. Kostić	Analysis of Galactic chemical evolution model compatible with measurements of interstellar deuterium abundance
D. Lukić	Astro climate: Astronomical Station Vidojevica
I. Milić	Astronomy department in Petnica Science Center
S. Milisavljević	Proximity calculation and changing of distance function
S. Ninković	Astronomy Olympiads - A challenge for future scientists
B. Surlan	Modeling of resonance line in inhomogeneous hot star winds
S. Tomić	Detection of a 1.59 h period in the B supergiant star HD 202850
V. Trajkovska	Astronomy in the media in Serbia
PSC students	MONECOM - A Collaborative Balkan School Project

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