I Workshop on
Astrophysical spectroscopy

Orašac 26-30. August 2011.

PROGRAM AND ABSTRACTS

Edited by Milan S. Dimitrijević

Society of astronomers of Serbia and
Group for Astrophysical Spectroscopy, Belgrade 2011

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Zoran Simić, Astronomical Observatory, Belgrade
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Venue

The workshop will be held in Vila Aleksandar in Orašac (see web site: www.aleksandarwellness.rs).

Scientific rationale

Spectroscopy is a power tool for the analysis of radiation from different plasmas in astronomy, laboratory, fusion research and industry. The investigation of nature of the emitting ionized gas in galactic nuclei is one of important subjects in astrophysics today. Investigating the processes in the central parts of these objects, we can learn about the innermost parts of other 'normal' galaxies. Moreover, AGN are the most powerful sources, located at different cosmological time-scales, and their investigation is cosmologically important. Additionally, a part of emission from these objects (e.g. in the X-rays) has its origin very close to a massive black hole, and investigation of this emission can help us understand the physical processes in a strong gravitational field.

On the other side, a number of AGN are affected by gravitational lensing effect. Studies aimed at determining the influence of microlensing on spectra of lensed quasars (hereafter QSOs) ought to account for the complex structure of the QSO central emitting region. Since the sizes of the emitting regions are wavelength-dependent, microlensing by stars in a lens galaxy will lead to a wavelength-dependent magnification.

Efficace theoretical analyzis, synthezis and modelling of stellar spectra as well as the spectra from other plasma sources, depends on atomic data and their sources. In particular for the modeling of stellar atmospheres and opacity calculations a large number of atomic data is needed, since we do not know a priori the chemical composition of a stellar atmosphere. Consequently the development of databases with atomic data and astroinformatics is important for stellar spectroscopy.

Investigation of spectral line profiles is of significance for various research fields not only in astrophysics, where, for example, by analysis of stellar line profiles we can obtain effective temperature, chemical composition, surface gravity and other data on the investigated star, but also for a number of topics in physics and technology

The workshop is planned as an opportunity to consider above mentioned aspects of spectroscopic research on plenary sessions and than to work on the special mini-projects, which will result in common papers to be published in international astronomical journals) during the workshop.

P R O G R A M

I Workshop on Astrophysical spectroscopy
Orašac 26-30. August 2011.

Friday 26.08.2011
11:00-11:30 Arrival and registration
11:30-12:00 Opening ceremony
12:00-13:00 Luka Popović: Spectroscopy as a tool for detection of super-massive binary black holes (Plenary IL)
13:00-13:30 Discussion on the common work and collaboration on problems in Spectroscopy of Active Galactic Nuclei

13:30-15:00 Lunch

15:00-19:00 Work in Sections 1-4 on Mini-projects

19:00 Dinner

Saturday 27.08.2011
10:00-11:00 Andjelka Kovačević: Virtual Atomic and Molecular Data Center – VAMDC and AOB Node. Present status and perspectives (Plenary IL)
11:00-11:30 Milan S. Dimitrijević STARK-B Database and Virtual Atomic and Molecular Data Center – VAMDC (IL)
11:30-12:00 Darko Jevremović Serbian Virtual Observatory, Virtual Atomic and Molecular Data Center – VAMDC and Astroinformatics (IL)
12:00-12:30 Discussion on Virtual Atomic and Molecular Data Center – VAMDC and its future role for Astrophysical spectroscopy research (Moderators Luka Č. Popović and Milan S. Dimitrijević)

13:00-15:00 Lunch

15:00-19:00 Work in Sections 1-4 on Mini-projects

19:00 Dinner

Sunday 28.08.2011

09:00-16:00 Excursion: Blagoveštenje Monastery, Risovača cave, Top of Mount Bukulja, Lunch in "Karadjordjev vajat"

17:00-19:00 Work in Sections 1-4 on Mini-projects

19:00 Dinner

Monday 29.08.2011

11:00-12:00 Dragana Ilić: Results of the long-term spectral optical monitoring of the active galaxy 3c390.3 (Plenary IL)

12:00-12:30 Vladimir Srećković: Radiative ion-atom collisions in stellar atmospheres (IL)

12:30-13:00 Discussion on the common work and collaboration on problems of Astrophysical Plasma research

13:00-15:00 Lunch

15:00-18:00 Work in Sections 1-4 on Mini-projects

20:00 Conference dinner

Tuesday 30.08.2011

10:30- 12:00 Work in Sections 1-4 on Mini-projects

12:00 Closing Ceremony

13:00 Departure

SECTIONS (S) and MINI PROJECTS (MP)

(Participants which will be present are marked by boldface. Other will participate in work by Skype or e-mail)

S1 Spectroscopy of Active Galactic Nuclei (Coordinator Luka Č. Popović)

MP1.1 Optical monitoring of High Energy Emitting Galactic Nuclei
Participants: **G. La Mura,** D. Bindoni, S. Ciroi, V. Cracco, F. Di Mille, F. Gabrielli, **D. Ilić, L. Č. Popović, P. Rafanelli**, L. Vaona

MP1.2 Validity of the virialization approximation of the broad lines in AGNs
Participants: **L. Č. Popović, J. Kovačević, G. La Mura**

MP1.3 Radiative transfer modeling of AGN dusty tori
Participants: **Jacopo Fritz, Marko Stalevski**

MP1.4 Spectroscopy of gravitational lensing
Participants: **L. Č. Popović, S. Simić**

S2 Astrophysical plasmas (Coordinator Anatolij Mihajlov)

MP2.1 The influence of the radiative non-symmetric ion-atom collisions in the stellar atmospheres in UV and VUV regions
Participants: Lj.M. Ignjatović, **A.A.Mihajlov**, **V.A. Srećković, M.S. Dimitrijević, A. Metropoulos**

S3 Astroinformatics and spectroscopic research (Coordinator Andjelka Kovačević)

MP3.1 AOB (ASTRONOMICAL OBSERVATORY – BELGRADE) NODE OF THE VIRTUAL ATOMIC AND MOLECULAR DATA CENTER

Participants: **A. Kovaćevič, M. S. Dimitrijević, L. Č. Popović, Z. Simić, D. Jevremović, J. Aleksić**

S4 Spectral line profiles in stellar and laboratory plasmas (Coordinator Milan S. Dimitrijević)

MP4.1 On the electron impact broadening of doubly charged magnesium ion lines

Participants: **Zoran Simić, Andjelka Kovačević,** Nébil Ben Nessib, **Milan S. Dimitrijević**, Sylvie Sahal-Bréchot

MP4.2 On the Stark broadening of Cr II $3d^5$ - $3d^4$4p lines in stellar atmospheres

Participants: **Zoran Simić, Milan S. Dimitrijević, Andjelka Kovačević**, Sylvie Sahal-Bréchot

MP 4.3 Stark broadening of B IV

Participants: **Milan S. Dimitrijević, Magdalena Christova, Zoran Simić, Andjelka Kovačević, Jovan Aleksić,** Sylvie Sahal-Bréchot

MP4.4 Calculation of Stark broadening of several Ne I lines for astrophysical purposes

Participants: **M. Christova, M. S. Dimitrijevic, Z. Simic,** Sylvie Sahal-Bréchot

ABSTRACTS

INVITED LECTURES

SPECTROSCOPY AS A TOOL FOR DETECTION OF SUPERMASSIVE BINARY BLACK HOLES

Luka Č. Popović

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Spectroscopy can be very useful in detection of super-massive binary black holes. Here we will discuss the possible emission of gas around binary black hole, and consider the changes in spectra (narrow and broad spectral lines) due to the existence of such objects.

VIRTUAL ATOMIC AND MOLECULAR DATA CENTER – VAMDC AND AOB NODE. PRESENT STATUS AND PERSPECTIVES

Andjelka Kovačević[1], Milan S. Dimitrijević[2,3], Luka Č Popović[2], Darko Jevremović[2], VAMDC Consortium (P. I. Marie-Lise Dubernet[4,5])

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Virtual Atomic and Molecular Data Center (http://www.vamdc.eu, VAMDC), an European Union funded FP7 project with the objective to create a secure, documented, flexible and interoperable e-science environment-based interface to existing atomic and molecular data, will be presented in this review. It will also provide a forum for dissemination and training of potential users.

Project leader is Marie-Lise Dubernet from Observatoire de Paris and core consortium is made of 15 institutions with 24 scientific groups from France, Serbia, Russia, England, Austria, Italia, Germany, Sweden and Venezuela.

The VAMDC facilities will be first of all useful for Astronomy, Plasma science, Atmospheric Science Radiation science and Fusion community as well as Industries using technological plasmas and Lightning industry and will represent a powerful tool for a better and easier search for the needed atomic and molecular data and an efficace data mining.

The participants of AOB (Astronomical Observatory – Belgrade) VAMDC Node are: Milan S. Dimitrijević, Luka Č. Popović, Andjelka Kovačević, Darko

Jevremović, Zoran Simić, Edi Bon and Nenad Milovanović. Recently, in this activity is also included Veljko Vujičić.

In this lecture, we will consider VAMDC, a good example of the global collaborations and development of new facilities in e-science. Also, we will present AOB VAMDC Node and our plans for its further development.

STARK-B DATABASE AND VIRTUAL ATOMIC AND MOLECULAR DATA CENTER – VAMDC

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The database STARK-B is a collaborative project between Laboratoire d'Etude du Rayonnement et de la matière en Astrophysique of the Observatoire de Paris-Meudon and the Astronomical Observatory of Belgrade. For the moment STARK-B contains Stark line broadening parameters (widths and shifts) obtained within the impact approximation using the semiclassical perturbation approach and the impact approximation. It is devoted for modelling and spectroscopic diagnostics of stellar atmospheres and envelopes, as well as for laboratory plasmas, laser equipment, inertial fusion plasma and technological plasmas.

STARK-B database is a part of the core of European Virtual Atomic and Molecular Data Center (http://www.vamdc.eu, VAMDC) e-infrastructure, one of the databases upon which it is based.

In this review, the STARK-B database will be presented as well as its connection with VAMDC.

SERBIAN VIRTUAL OBSERVATORY, VIRTUAL ATOMIC AND MOLECULAR DATA CENTER – VAMDC AND ASTROINFORMATICS

Darko Jevremović, Milan S. Dimitrijević, Luka Č. Popović, Jovan Aleksić

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SerVO - Serbian virtual observatory (http://www.servo.aob.rs/~darko) started as a project whose funding was approved through a grant TR13022 from Ministry of Science and Technological Development of Republic of Serbia, with duration of 33 months from April 1st 2008 till December 31st 2010. From the 1st January of 2011, SerVO is financed by the Ministry of Education and Science of Republic of Serbia through the project III44002 "Astroinformatics and virtual observatories". After establishing SerVO and

starting to digitize and archive photo plates and other astronomical data produced at Belgrade Astronomical Observatory, the aims are: i) To work on the development of SerVO and to join the EuroVO and IVOA; b) To develop SerVO data Center which will work on the digitizing, archiving and publishing in VO format photo-plates; c) To work on the development of tools for visualization of data; d) Make a regional node of Virtual Atomic and Molecular Data Center – VAMDC; e) Make a mirror site of STARK-B - Stark broadening data base containing as the first step Stark broadening parameters, obtained within the semiclassical perturbation approach and impact approximation, in VO compatible format; f) Make a mirror site for DSED - Darthmouth Stellar Evolution Database in the context of VO, and g) to put online electronic editions of serbian astronomical institutions.

In this review, the SerVO will be presented, and its history, aims and future plans, as well as its connections with European Virtual Atomic and Molecular Data Center (http://www.vamdc.eu, VAMDC), and its node on Belgrade Astronomical Observatory will be considered.

RESULTS OF THE LONG-TERM SPECTRAL OPTICAL MONITORING OF THE ACTIVE GALAXY3 C390.3

Dragana Ilić[1], Luka Č. Popović[2], Alla I. Shapovalova[3], Andjelka Kovačević[1], Nikolai G. Burenkov[3], Vahram H. Chavushyan[3]

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The structure of the broad line region (BLR) in active galactic nuclei (AGN) is still not well known. The BLR is close to the central supermassive black hole and may hold basic information about the formation and fueling of AGN, as well as of the mass of the black hole in the center.

The AGN are highly variable objects. Especially their broad emission lines (BEL) are changing dramatically. The investigation of the BEL flux and profile variability in a long period is very useful for mapping the geometrical and dynamical structure of the BLR.

Here we present the result of the long-term spectral optical monitoring of a well know radio-loud AGN 3c390.3 that exhibit interesting double-peaked BEL profiles.

RADIATIVE ION-ATOM COLLISIONS IN STELLAR ATMOSPHERES

Vladimir A. Srećković[1], Anatolij A. Mihajlov[1], Ljubinko M. Ignjatović[1], Milan S. Dimitrijević[2,3], Aristophanes Metropoulos[4]

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In this lecture, we will present results of our investigations of the influence of the processes of radiative charge exchange in symmetric and strongly non-symmetric ion-atom collisions on the opacity of solar and stellar atmospheres in UV and VUV regions. We considered several ion-atom systems ($H + H^+$, $He + He^+$, $He + H^+$ and $H + A^+$, where A = Li, Na etc.) and determined some characteristics, such as molecular potential curves and dipole matrix elements. They were used for the determination of coefficients of spectral absorption due to examined processes, together with the corresponding molecular photo-dissociation processes, in the atmosphere of the Sun and some DB white dwarfs. It was found that the influence of the considered processes should be taken into account for modeling of stellar plasma and analysis and synthesis of stellar spectra, since for example these processes generate rather wide and firm molecular absorption bands in the UV and VUV regions, which neglection will introduce errors in the interpretation of the observational data.

MINI PROJECTS

OPTICAL MONITORING OF HIGH ENERGY EMITTING GALACTIC NUCLEI

G. La Mura[1], D. Bindoni[1], S. Ciroi[1], V. Cracco[1], F. Di Mille[1], F. Gabrielli[1], D. Ilić[2], L. Č. Popović[3], P. Rafanelli[1], L. Vaona[1]

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Approximately 20% of nearby galaxies show hints of energetic activity in their nuclear regions, through the presence of appreciable amounts of ionized gas. The source of activity is most often identified either with very young stellar populations, dominated by hot, massive stars, or with non-thermal processes occurring in the galactic nuclei.

Nowadays it has been realized that both possibilities take an important part in the evolution of galaxies. Indeed, there is increasingly strong observational evidence suggesting that nuclear activity and star formation are likely to be physically connected. However, to investigate whether there is a cause-effect relationship between these two phenomena, we have to investigate the properties of galaxies, the masses of which are in the critical range where starburst activity and AGN activity are more likely to be found (Rafanelli et al. 2011). In this project, we propose to operate the newly upgraded 1.22m telescope in Asiago to start a monitoring campaign of a list of such objects selected also on the basis of their high energy emission (X and gamma rays). Variable high energy emission, indeed, is considered as an effective track of AGN related processes. Our idea is to exploit the Asiago observatory as an optical facility to perform observations of objects, which are studied at high energies, too. Taking advantage from multiple frequency observations, it is our aim to improve the current understanding of nuclear activity in galaxies, investigating the dynamics of AGN central engines, as well as the properties of galaxies where ongoing star formation is probably overlapping with nuclear activity.

VALIDITY OF THE VIRIALIZATION APPROXIMATION OF THE BROAD LINES IN AGNS

Luka Č. Popović[1], Jelena Kovačević[1], Giovanni La Mura[2]

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The broad lines of AGNs are used to measure the mass of black hole, supposed to be in their center. Here we are going to check validity of virilization approximation of broad lines in AGNs. We measured widths of broad lines at 1/10, 1/5, 1/2 and 3/4 of the maximal intensity, and plot their ratios as a function of full width at maximal intensity. Using this plots we will be able to conclude how much is emitting gas gravitationally bounded.

RADIATIVE TRANSFER MODELING OF AGN DUSTY TORI

Jacopo Fritz[1], Marko Stalevski[2]

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The inner regions of AGN (accretion disk and BLR) are surrounded by the toroidal structure composed of dust. This dusty torus absorbs the incoming radiation from the accretion disk and re-emits it in the infrared domain. Thus, to study the observed shape and features of spectral energy distributions (SED) in the infrared, radiative transfer modeling of dusty torus is necessary. During the workshop, the participants in this section will discuss further development and applications of the two-phase model of dusty torus presented in Stalevski et al. (2011). The topics to be covered include: investigation of different dust compositions, SED variations due to the changes in the inner torus structure, influence of size of clumps and their actual arrangement on SED.

SPECTROSCOPY OF GRAVITATIONAL LENSING

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The GAIA mission will be able to perform precise measurements of order of hundredth part of millisecond of arc. This will provide possibility to measure off-center changing of lensed quasars due to microlensing. Here we will investigate expected photocenter variability of lensed quasars due to microlensing. We will take into account the spectral bands in which the GAIA will work.

THE INFLUENCE OF THE RADIATIVE NON-SYMMETRIC ION-ATOM COLLISIONS IN STELLAR ATMOSPHERES, IN UV AND VUV REGIONS

Ljubinko M. Ignjatović[1], Anatolij A. Mihajlov[1], Vladimir A. Srećković[1], Milan S. Dimitrijević[2,3], Aristophanes Metropoulos[4]
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The aim of this work is to draw attention to the processes of radiative charge exchange in strongly non-symmetric ion-atom collisions as factors of influence on the opacity of stellar atmospheres in UV and VUV regions. Therefore, for several ion-atom systems ($He + He^+$ and $H + A^+$, where A = Li, Na etc.) some characteristics have been determined, such as molecular potential curves and dipole matrix elements. Then, using these characteristics, calculations have been carried out to determine coefficients of spectral absorption due to these processes together with the corresponding molecular photo-dissociation processes, in the atmosphere of the Sun and some DB white dwarfs. The standard models of the considered atmospheres have been used in the calculations. It has been established that the examined processes generate rather wide and firm molecular absorption bands in the UV and VUV regions, which should be taken into account at interpretation of the data obtained from measurements.

AOB (ASTRONOMICAL OBSERVATORY – BELGRADE) NODE OF THE VIRTUAL ATOMIC AND MOLECULAR DATA CENTER

Andjelka Kovačević[1], Milan S. Dimitrijević[2,3], Luka Č Popović[2], Zoran Simić[2], Darko Jevremović[2], Jovan Aleksić[2]

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We will consider and discuss actual status and plans for the future development and activity of Serbian AOB (Astronomical Observatory – Belgrade) Node of Virtual Atomic and Molecular Data Center (http://www.vamdc.eu, VAMDC), an European Union funded FP7 project: Also, we will discuss activities, needed that AOB Node of VAMDC becomes a regional center for the connection of activities on atomic and molecular data, and an organizer of regional trainings for students and potential users, as well as a VAMDC Node for monitoring the needs of users in South Eastern Europe.

ON THE ELECTRON IMPACT BROADENING OF DOUBLY CHARGED MAGNESIUM ION LINES

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Broadening of spectral lines by collisions with charged particles is of interest for a number of topics in astronomy and physics, like for astrophysical, laboratory, laser produced, fusion or technological plasma investigation, modelling and diagnostics. Magnesium is an element of particular astrophysical importance due to its high cosmic abundance. For example Solar abundance of magnesium is the largest after H, He, O, C, Ne and N. Moreover, carbon burning in stellar interiors of some massive stars produces oxygen-neon-magnesium cores.

Within the semiclassical perturbation approach, using the impact approximation, we will consider ab intio, using the Cowan code for the needed energies and oscillator strengths, Stark broadening parameters for several Mg III lines. In addition to electron-impact full halfwidths and shifts, Stark broadening parameters due to proton-, and doubly charged helium ion-impacts
will be investigated as well, in order to provide Stark broadening data for the important charged perturbers in stellar atmospheres.

The obtained results will be compared with the available theoretical results.

ON THE STARK BROADENING OF Cr II $3d^5$ - $3d^4 4p$ LINES IN STELLAR ATMOSPHERES

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Chromium lines are interesting due to their presence in stellar atmospheres. They have been identified in stellar spectra, as for example o Peg, 7 Sex, and φ Aqu, in which spectrum Caliskan and Adelman identified 28 Cr II spectral lines and noted overabundace with value log Cr/H = -5.85±0.27. Consequently, data on the Stark broadening of single ionized chromium spectral lines are of interest not only for laboratory but also for astrophysical plasma research. Of particular interest are resonance lines, since they are often present in stellar spectra.

We analyze here, the importance of Stark broadening effect for Cr II $3d^5$ - $3d^4 4p$ transitions in stellar atmospheres.

STARK BROADENING OF B IV

Milan S. Dimitrijević[1,2], Magdalena Christova[3], Zoran Simić[1], Andjelka Kovačević[4], Jovan Aleksić[1], Sylvie Sahal-Bréchot[2]

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The light elements lithium, breryllium and boron are of particular interest since they undergo nuclear reactions at relatively low temperatures reached in the solar-type stars outside the core, so that their circulation and destruction can produce observable changes in abundances, providing informations on stellar structure and mixing by convection. Boron lines are observed in Sun and stars. For example Proffitt and Quigley (2001) studied B III 2065.8 Å resonance line in 44 early B type stars determining the abundance of boron. In this work we will determine within the impact approximation, by using the semiclassical perturbation theory, Stark broadening parameters for B IV lines,

needed for stellar plasma research and modelling, as well as for a number of research topics in plasma physics. The obtained data will be used to investigate the influence of Stark broadening of spectral lines in stellar atmospheres.

CALCULATION OF STARK BROADENING OF SEVERAL Ne I LINES FOR ASTROPHYSICAL PURPOSES

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Neon lines are present in stellar spectra and due to its high cosmical abundance, as well as to the fact that carbon burning in stellar interiors produces oxygen-neon-magnesium cores, this element is particularly interesting for astrophysical plasma research, including the Stark broadening of lines in its spectrum. For example the Solar abundance of neon is the largest after H, He, O and C. Here, we will investigate Stark broadening of neon spectral lines within the series $2p^5 3p\ ^2[5/2]_3 – 2p^5 nd\ ^2[7/2]^\circ_4$. The new Stark broadening parameters will be determined using the semiclassical perturbation approach and the impact approximation. The obtained results will be used for the investigations of regularities and systematic trends of Stark broadening parameters within a spectral series and for the investigation of the influence of Stark broadening in stellar spectra.

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