Proc. VI Serbian-Bulgarian Astronomical Conference, Belgrade 7-11 May 2008,
Eds. M. S. Dimitrijević, M. Tsvetkov, L. Č. Popović, V. Golev
Publ. Astr. Soc. "Rudjer Bošković", No. 9, 2009, 321-326

MODELLING THE STELLAR POPULATION IN ACTIVE GALAXIES

NATAŠA GAVRILOVIĆ[1,2]

[1]*Astronomical Observatory, Volgina 7, 11060 Belgrade, Serbia*
e-mail: ngavrilovic@aob.bg.ac.yu
[2]*Observatoire de Lyon, 9 avenue Charles André, Saint-Genis Laval, Cedex F-69561, France*
e-mail: natasa.gavrilovic@obs.univ-lyon1.fr

Abstract. We present our analysis of synthetic spectrum composed of AGN and stellar population spectra. The goal of my thesis project is to fit an AGN spectrum against a composite model consisting of emission line systems and of the underlying stellar population (absorption line spectrum). As a first exercise I reproduced the test made by Prugniel et al. (2005) to evaluate the ability to disentangle the stellar population and AGN spectra. I succeeded to reproduce this test and obtained similar results: The method efficiently restore kinematics, age and metallicity of the stellar population, as well as the AGN contribution to the continuum.

1. INTRODUCTION

In order to analyze an AGN spectrum, it is important to be able to subtract the stellar population (SP) component and to give an estimation of an AGN contribution to the observed spectrum.

In order to subtract the SP, we have to fit the stellar component and the continuum in the same time. Once we fit the SP, we are able to analyse the kinematics of the stellar component and the dependences between the gas and stellar motion in the galaxy.

The goal of my thesis project is to fit an AGN spectrum against a composite model consisting of emission line systems and of the underlying stellar population (absorbtion line spectrum).

As a first exercise I reproduced the test made by Prugniel et al. (2005).

The goal of this test was to evaluate the ability to disentangle the stellar population and AGN spectra and more specifically to assess the reliability of the determination of the age and metallicity of a stellar population underlying an AGN. The regions of the emissions lines are excluded from the population fit, and the population spectrum is diluted by the continuum nebular emission. Here are presented results of this exercise.

2. FIT PROCEDURE

We simulated composite AGN+ stellar population spectrum, and fitted that spectrum in order to test the accuracy of our fitting procedure and results obtained from the best fit.

For the AGN spectrum we have used NGC 1068 one (Kinney 1996[1] from HyperLeda database[2]), while for the stellar population spectrum we used PEGASE.HR (Le Borgne et al. 2004) spectrum with Solar-like characteristics (age=5000 Myr and metallicity=0.00 dex). We smoothed the AGN spectra in order to smear out the signature of the stellar population of the real AGN. Since we used high smoothing factor, [OIII]λλ 4959,5007 lines cannot be resolved, and Hβ almost disappeared. At this first point we did not fit emission lines. Therefore, they were masked during the fit.

In order to increase the velocity dispersion of the template, we convolved template of SP spectra with the Gaussian which velocity dispersion was 100 km/s.

We cut both spectra in the wavelenght range λ=4200-5600 Å, and rebinned them in logarithmical scale to have the same step.

Since clear AGN spectrum does not have emission lines at λ=5100 Å, we consider the intensity at that point in both spectra, in order to simulate different contribution of stellar and AGN component. We analysed three cases: 0%, 25% and 50% of AGN contribution to the total spectrum.

3. ANALYSIS OF THE STELLAR POPULATION IN AGN

In order to analyse stellar population in AGN, we fitted simultaneously SP spectrum and AGN continuum.

For the fit we have used the program NBURSTS developed on the Lyon's Observatory (Chilingarian et al. 2007, Koleva et al. 2008). The program performs a Levenberg-Marquart minimization and can fit a combination of SSP. The population models are spline interpolated over an age-metallicity grid of models, generated with PEGASE.HR with free age, metallicity and multiplicative polynomial continuum. It is written in IDL/GDL starting from PPXF[3] and uses the MPFIT[4] procedure.

The principle of the analysis is to compare an observed spectrum of a stellar population with a model in order to derive (i) the characteristics of the stellar population (age and metallicity), (ii) the internal kinematics (mean stellar velocity

1 Original address: ftp.stsci.edu/pub/catalogs/nearby_gal/sed.html
2 http://leda.univ-lyon1.fr
3 http://www.strw.leidenuniv.nl/˜mcappell/idl/
4 Markwardt, http://cow.physics.wisc.edu/˜craigm/idl/idl.html

and velocity dispersion) convolved by the line-of-sight velocity distribution and (iii) fraction of an AGN continuum.

Since Moultaka (2005) showed that the stellar population composition is highly affected by the presence of an additive continuum (e.g. the presence of an AGN or heated dust in the IR case) if this continuum is not modeled in the synthesis, we fitted simultaniously stellar absorption lines and AGN continuum. For the fit of the AGN continuum we used Legendre polynomial of the ninth order.

We incorporate a multiplicative polynomial into the fit to remove large-scale shape differences between the observed stellar and galactic spectra caused by the differences in instrumental throughput as a function of the wavelength (Kelson et al. 2000). The polynomial represents a linear combination of Legendre polynomials. The polynomial of 28^{th} order was chosen to absorb any flux calibration systematics or effects of extinction.

4. RESULTS

In the Table 1. are presented the results obtained from the best fit in three experiments, taking into account 0%, 25% and 50% of the AGN contribution to the composite spectrum. Results of all three experiments show that characteristics of the SP are not dependent on the AGN contribution in an analyzing spectrum.

Table 1: The table lists initial values of the parameters (the first column) and the fit results of three experiment where *v* represents mean stellar velocity, σ velocity dispersion, *z* metallicity, *f* the restored fraction of AGN and χ^2 represents the goodness of the fit.

	init. values	***AGN 0%***	***AGN 25%***	***AGN 50%***
v (km/s)		0.005 ± 0.429	-0.189 ± 0.621	-0.271 ± 0.940
σ (km/s)	100	99.938 ± 0.472	100.633 ± 0.702	101.655 ± 1.072
age (Myr)	5000	5005.002± 124.993	5107.514 ± 206.790	5471.663 ± 355.565
z (dex)	0	0.0006 ± 0.009	0.009 ± 0.013	-0.006 ± 0.020
f (%)		0.1	25.4	49.6
χ^2		2.62e-5	0.018	0.038

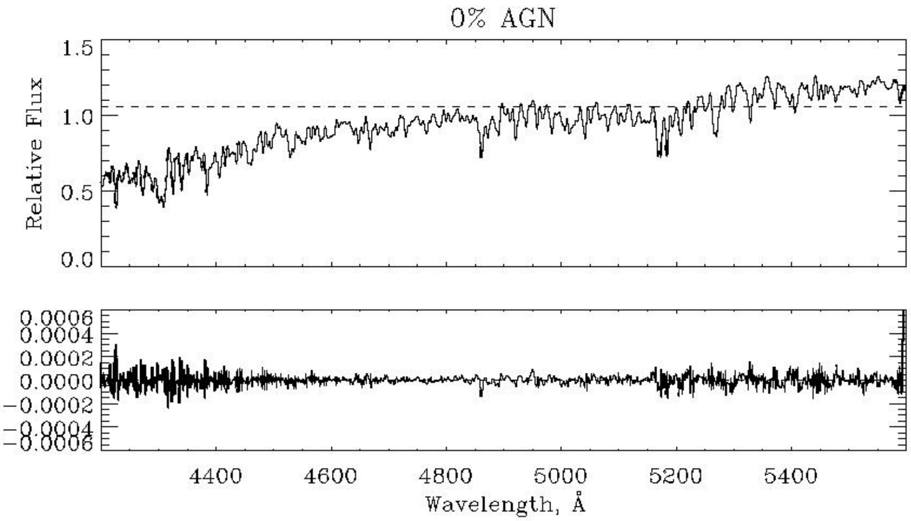

Figure 1: The fit of the pure SP. The first plot shows input spectrum and the best fitted model (since the residuals are very low, the difference between the input spectrum and best fitted model can not be resolved). Plot below show residuals of the fit.

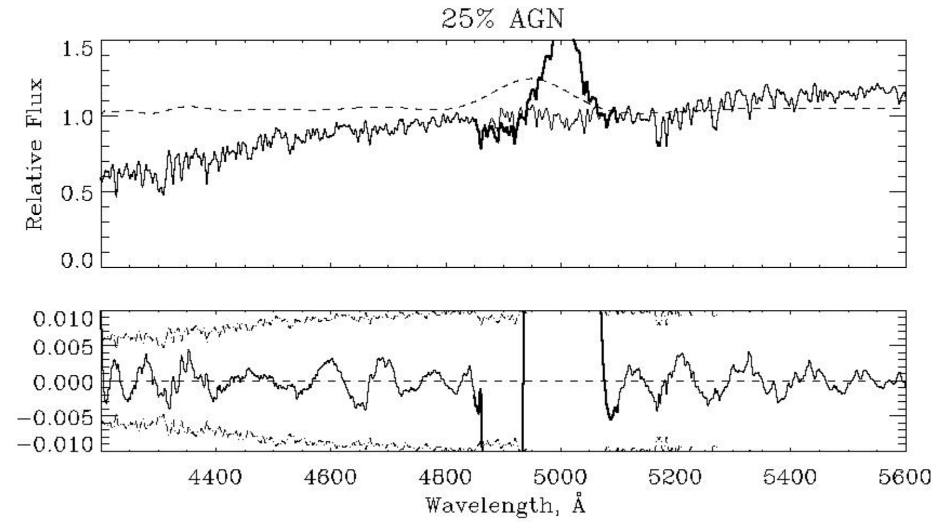

Figure 2: The fit of simulated spectra with 25% of AGN contribution to the total spectrum. The first plot shows input simulated spectra (full line), best fitted model (full line (on this plot simulated spectrum and best fitted model can not be re-solved)) and multiplicative continuum (dashed line), while the plot below shows residuals of the fit (full line) and noise (dashed line). Strong full line represents masked emission lines. The continuum is plotted in the reciprocal way.

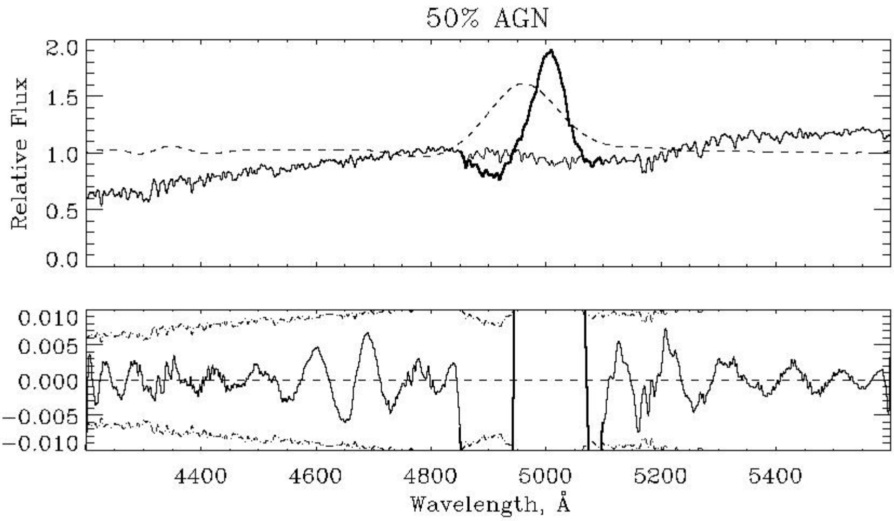

Figure 3: Fit of simulated spectra with 50 % of AGN contribution. The description of the figure is the same as for the Fig. 2.

5. CONCLUSION

We succeeded to reproduce the tests performed in Prugniel et al. (2005) with the same analysis method and obtaining a similar result.

One can see from the Table 1. that used analysed method based on pixel fitting with PEGASE.HR spectra can efficiently constrain kinematics, as well as age and metallicity of the underlying stellar population in AGN spectra. In a difference with results of Prugniel et al. (2005), we succeed to restore also the AGN emission fraction in the analysed spectra.

Since we showed that our fitting procedure is giving highly accurate results, the subtraction of the fitted SP from the composite spectrum gives the AGN spectrum, cleaned for the SP contribution. This is very important step in analysing the AGN emission, mostly in the case of low luminous galaxies as Sayfert 2 or LINERs.

Acknowledgment

I would like to thank my supervisors P. Prugniel and L. Č. Popović for the constructive remarks during the work on this progress report.

References

Chilingarian, I., Prugniel, P., Sil'Chenko, O. K., Afanasiev, V. L.: 2007, *Mon. Not. R. Astron. Soc.*, **376**, 1033.
Kelson, D. D., Illingworth, G. D., Dokkum, P. G., Franx, M.: 2000, *Astrophys. J.*, **531**, 137.
Koleva, M., Prugniel, P., Ocvirk, P., Le Borgne, D., Soubiran, C.: 2008, *Mon. Not. R. Astron. Soc.*, **385**, 1998.
Le Borgne, Rocca-Volmerange, B., Prugniel, P., Lançon, A., Fioc, M., Soubiran, C.: 2004, *Astron. Astrophys.*, **425**, 881.
Moultaka, J.: 2005, *Astron. Astrophys.*, **430**, 95.
Prugniel, P., Chilingarian, I., Popović, L. Č.: 2005, *Mem. S. A. It.,* **7**, 42.