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Stellar population synthesis in AGNs

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Abstract. We present a numerical code to synthesize the stellar population of galaxies, using the observed flux as observable, for the visible and IR range This code is an evolution of a previous one, which used the equivalent widths.

1. Model

To compute stellar population synthesis, we favour the inverse approach, where the population is synthesized in terms of observables. In this approach, stellar history is used only to introduce constraints. In order to avoid the ambiguities and to minimize the age/metallicity degeneracy, we have to consider many stellar features sensitive to various atmospheric parameters. Two different types of observables can be used: the equivalent widths (Pelat 1997, 1998; Moultaka & Pelat 2000; Boisson et al. 2000) or the fluxes.

Using the flux increases the number of observables. It also allows to account for additional featureless components such as the emission of hot dust, AGN continuum and/or different extinction laws for different stellar types. But there are a few drawbacks: we can have a reddening versus hot stars degeneracy of the solutions, especially when we work on galaxies which present faint features of absorption; reddening introduces an additional unknown to the problem and makes it non–linear.

The method is a revival of the quadratic programming first introduced by Faber(1972). It is required to perform proper error analysis, both for the statistical and the systematic errors. Due to the non unicity of the solution, the systematic errors should be treated in a way similar to the one used for the EW method.

In order to perform the synthesis, the stellar library spectra are spectrally binned to match the observed galaxy sampling, using Fourrier interpolation. Velocity dispersion broadening of lines in the galactic spectrum is also taken into account.

The minimization of a quadratic form makes it possible to obtain the percentages of the contribution of each star composing the stellar database to the synthetic galactic spectrum. For that, we used a routine coming from the GALAHAD package (Gould et al. 2002). The reddening parameter E(B–V) of the galaxy is determined by a χ^2 minimization.

2. Results

Spectra of 12 galaxies of different level of activity have been synthesized. See Figure 1(left) for an example. The results obtained are generally in good agreement with those of the EW method (see Boisson et al. 2000). For the Seyfert 2, however, the degeneracy between reddening and hot stars in the flux method leads to synthetic spectra with too strong a contribution from hot stars. To avoid this problem, we are working on a new version of the code, using the red part of the spectrum as a constraint to minimize the blue part.

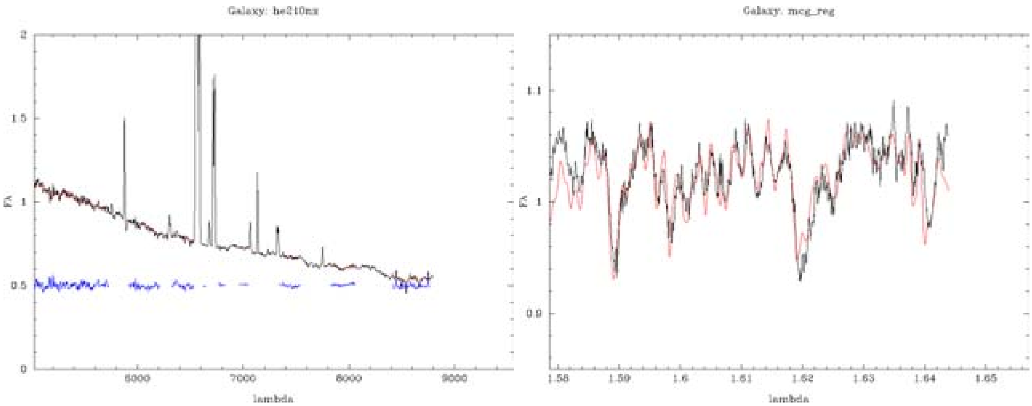

Figure 1. Left Observed (in black) and synthetic (in grey) spectra in relative flux of the inner part (90 pc) of the starburst galaxy He2–10 ; difference between the 2 spectra at the bottom. **Right** IR range : Observed (in black) and synthetic (in grey) spectrum of MCG–6–30–15.

The red part is indeed less dependant on the reddening. The χ^2_R minimum found for the red part is used as a radius of the area inside which we minimize the χ^2_B of the blue part.

3. IR Domain

The domain $1.57 - 1.64\mu m$ in the H band, which is clear of strong emission lines, allows us to sample the stellar content of the very nucleus. It has very good luminosity discrimators (Dallier et al. 1996). We use the stellar library from Meyer completed by a few super–metallic stars. The synthetic spectrum obtained with the flux method for the highly reddened Seyfert 1 MCG–6–30–15 is shown in Figure 1 (right). Hot dust emission contributes between 45% and 50% of the total flux.

Unfortunately, the IR stellar library used for this synthesis is far from completeness. For this galaxy, due to a lack of super–metallic giant stars, an important contribution of cold supergiant stars occurs (incompatible with the absence of young hot stars) in the place of SMR giants which we found in MCG–6–30–15 in the optical range.

To avoid this kind of problem, we really need some new high spectral resolution observations of metallic stars. A good flux calibrated spectral library for the IR range, of observed or theoretical stars, is mandatory.

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