Host galaxies of AGN

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Abstract.

The relationship of an AGN to its host galaxy is a crucial question in the study of galaxy evolution. We perform stellar population synthesis in the central regions of galaxies of different activity levels. A large number of stellar features are measured both in the optical and near-infrared.

We find the nuclear stellar population to be related to the level of activity. These differences are no more conspicuous further away in the bulge of the galaxy.

1. Introduction

An unsolved issue in understanding the Seyfert phenomenon is the relation between the Seyfert type of activity and its host galaxy. A number of studies have found a connection between nuclear activity and strong star formation in the host galaxy. Studying host galaxy of Active Galactic Nuclei (AGN) can help answering questions relevant to the understanding of AGN but also to galaxy formation and evolution such as: how does the AGN affect the host galaxy? Is there a direct link between the activity level of the AGN and the starburst activity? Is the starburst activity nuclear or circum-nuclear? What about the age and metallicity of the host galaxy stellar population.

In order to answer to some of these questions, we perform stellar population synthesis of the integrated starlight emitted in the central 10 arcsec of nearby Active Galaxies in the optical and near-IR range. The good spatial resolution now achievable allows to detect gradients of population and starburst activity in the central region of the galaxies.

2. Observations

Long slit spectroscopy of a sample of AGN, including 5 Seyfert 1, 5 Seyfert 2, 3 LINERs and 2 Starburst galaxies was obtained in the visible; 2 Seyfert 1 and 3 Seyfert 2 were also observed in the H band.

In the optical, observations were obtained with the Herzberg at CFHT (Serote Roos et al., 1998) and with EMMI at NTT, in the range 5000-9000Å with a resolution of FWHM=10Å. Spectra are extracted from the central 3-4 arcsec, as well as from surrounding regions located at 5 to 7 arcsec from the center, i.e. within the bulge at the distance of the galaxies. Up to 47 stellar
Numerous metallic stellar features can be identified.

In the near-infrared domain there is a much better contrast of galaxy light to nuclear light. This domain allows to view the host galaxy with less contamination from the nucleus than is possible in the visible. Moreover cool stellar populations are best studied as their spectral energy distribution peaks near 1$\mu$m. Also it allows to probe obscured objects since extinction effects are much less important at these wavelengths. The H band was favoured as it is remarkably rich in strong metallic features and exhibits powerful luminosity indicators (Dallier et al., 1996). ISAAC at VLT, in Medium Resolution mode, provides a resolution of FWHM=5$\AA$. In the range 1.56-1.64$\mu$m, 30 metallic stellar features are identified, among which some line ratios are strongly dependent on the luminosity class of the stars, while quasi no emission lines from the AGN are present (Fig. 1). A flux calibrated stellar library at a resolution R=2000 is available (Dallier et al., 1996) and is being extended for a better coverage of the H-R diagram.

3. Synthesis.

There are two ways of computing stellar population synthesis. The direct approach presupposes perfect knowledge of the stellar evolution in order to create appropriate model to a composite population with specified age, metallicity and star formation rate. The inverse approach where populations are synthesized in terms of observables. In this approach, the one we favour, stellar evolution is used only to introduce constraints as to lower the number of possible solutions and give more weight to the adopted solution.

To compute stellar population synthesis, we compare the equivalent width (EW) of numerous stellar features observed in the galaxy to the EW of the same
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Figure 2. Synthetic spectra (black line) superimposed on the observed one (grey line)

lines measured in a library of star spectra. Recall that EW are independent of reddening.

We get a system of non-linear equations solved using a method developed by Pelat (1997 and 1998) and Moultaka and Pelat (2000) which determines the best solution. The advantage of this method is that no hypothesis on the IMF, or on the history of star formation is made, and no evolutionary track models are preferred. It gives the contribution of each stellar type to the total radiation at a reference wavelength and the standard deviation to these contributions.

Synthetic spectra are computed using the stellar library. Intrinsic reddening is deduced from the comparison of the overall shape of the observed and synthetic spectra.

An example of the results obtained in the optical range is shown Figure 2 where the synthetic spectrum of each region extracted from one of the LINER galaxies are superposed to the observed spectrum after correction of the internal reddening.

Such a study in the optical lead to two important results i) the stellar populations within a class of AGN activity, whatever the morphological type of the host galaxy, is very homogeneous and ii) the populations are different in the very central regions of Seyfert 2 and LINERs (Boisson et al., 2000 & 2001). LINERs have a very old metal rich population while in Seyfert 2 a contribution of weak or old burst of star formation is observed in addition to the old high metallicity component (in comparison, Starbursts have a stronger and younger stellar population).

In the infrared, the work is still in progress. But some hints of the power of combining optical and infrared bands can be given. Figure 3 displays the spectrum of a circumnuclear region, located at 360pc from the center, of the Seyfert 1 galaxy MCG-6-30-15. The spectral features are similar to those in the nucleus (within a radius R=180pc) although quite different in strength,
indicating that the stellar population may be the same in both regions but that in the nucleus stellar features are diluted by a continuous emission. This diluting continuum may be due to dust emission, in which case if one assumes no gradient of population, the comparison of the overall shape of the spectra indicate a dust temperature of about 1000K.

Figure 4 shows the optical spectrum of the same region with the synthetic spectrum superimposed. The stellar population synthesis indicates the presence of 67% dwarf and 23% giant stars. At 1.6$\mu$m this translates into 12% dwarf and 88% giant stars with 60% M giants and 20% K giants. In Figure 5 we show this “translated” synthetic stellar population diluted by 20% host dust on top of the nuclear spectrum of MCG-6-30-15. The comparison is quite encouraging.

4. Conclusions.

The stellar population in the inner regions of AGN are related to the level of activity of the AGN. These differences are no more conspicuous further away in the bulge of the galaxies. A relationship between the nucleus activity and circumnuclear starburst is advocated.

The near-infrared domain allows to study as well the very nucleus of Seyfert 1 as evidenced in the case of MCG-6-30-15. Future full spectral synthesis in the IR spectra will be performed.

References

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Figure 4. Synthetic spectrum of MCG-06-5-30 (black line) superimposed on the observed optical one (grey line).

Figure 5. “Translated” optical synthesis spectrum (grey line) superimposed on the nuclear infrared spectrum of MCG-06-5-30 (black line).
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