A panchromatic view of quasars from surveys

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Quasars are the most luminous persistent sources in the Universe, and as such they represent essential "laboratories" for physics and astrophysics. Determining their broad-band spectral properties, their dependence on physical parameters such as luminosity and black hole mass and their possible evolution with redshift, is key to understand the physical processes determining their emission, and their role in the evolution of the Universe. Several relations among physical parameters and observational spectral features are known (e.g. Black hole virial relations, Baldwin Effect, $L_X - L_{UV}$ relation), but there is no strong evidence of any evolution with cosmic time from the comparison of high redshift quasars with local ones. My master thesis project was aimed at carefully analyzing quasar spectra in the optical, Near-InfraRed and X-Ray bands with different luminosities, redshifts and masses and provided a strong confirmation of the independence of the main observational properties of quasars from their redshift.

In addition to this, in the past few years quasars have become relevant as cosmological probes, thanks to several new methods to estimate their distances with increasing precision. Some examples are the use of water maser emission to provide an anchor to the Cepheid period-luminosity relation in NGC 4258, the distance estimates based on reverberation mapping of both lines and continuum emission, trigonometric parallax by Spectro-Astrometry and Reverberation Mapping, UV and X-ray emission ratios. All together, these techniques are contributing to create a new class of "standardized candles" which, if carefully selected and modelized, can produce valid results for precision cosmology and cooperate to supply further constraints on cosmological parameters.

In my project I propose to study the spectro-photometric properties of quasars over the widest possible spectral range and the largest interval of physical parameters, such as the central black hole mass, the bolometric luminosity,the Eddington ratio and the redshift. The ultimate goals of this project are:

- To confirm that quasars can be used as reliable and precise *Standard Candles* through their multi-wavelength spectral correlations depending on luminosity (and not on redshift).
- To unveil the physical process linking the accretion disk and the X-Ray emitting *Corona*, an outstanding problem that can be investigated by mean of the X-Ray to UV luminosity relation.
- To understand the role of quasar feedback in the evolution of galaxies, in particular by analyzing the spectral features of the outflows in X-Ray weak quasars.

This project will take advantage of both available public catalogues of quasars in a broad wavelength range, from X-Ray to IR, as well as new dedicated observations, for example on luminous, high-redshift quasars with the Large Binocular Telescope which can provide precious information on significant emission lines (e.g. MgII 2798 Å) for the determination of BH masses and luminosity distances even at high z.

By cross-matching recent large surveys it is possible to investigate the aforementioned properties on large quasar samples inferring important information on the properties of the quasar population and on whether they evolve on cosmological scales: this is done by performing one by one dedicated spectral line and continuum fitting of the sources or stacking together sources that share similar properties. A multi-band approach, from X-ray through visible/UV to IR allows, with a careful luminosity cross-calibration, to describe the whole characteristic quasar SED.

Moreover, the analysis of these large data surveys allows to select relevant homogeneous subsamples, discarding sources that show features deviating from the "standard" quasar (e.g. BALs, reddening, outflows, blazars), even though the definition of a "mean quasar" is not straightforward by any means, and still conserving enough statistics for significant results.
On the other hand a complementary analysis will be dedicated to objects discarded from the homogeneous sample and the physics of the peculiarities that ruled them out of the sample, since they could give important insights into the complex quasar environment.

The practical tasks I plan to perform on these samples in order to achieve the scientific goals of the project are:

- I will study broadband AGN spectra and photometry over a vast range of characteristic parameters even at high z.
- I will extract samples of "standard quasars" to study the physics of the central engine and its surroundings, limiting secondary effects.
- I will extract samples for cosmological purposes through various of the aforementioned techinques, hence putting constraints on fundamental parameters.
- I will evaluate the cosmological evolution of the characteristic parameters of quasars, an important theme in AGN population studies.
- I will analyze absorption features, key to understand quasar outflows and their feedback on host galaxies.

Whereas this project is based on the experience of my Master thesis, I wish to expand my scientific interests working also with some other groups abroad since I regard as fundamental to develope international cooperations and to get a more comprehensive perspective on these topics and on extragalactic astrophysics in general.