Spectral energy distribution template of redshift-zero AGN and the comparison with that of quasars

Almudena Prieto
Instituto de Astrofísica de Canarias, Tenerife, Spain

Abstract. Spectral energy distributions (SEDs) of the central few tens of parsecs of some of the nearest active galactic nuclei (AGN) have been used to construct a genuine redshift-zero SED template [1]. This paper presents the comparison between this redshift-zero template and those of the radio loud and radio quiet quasar templates by [2]. Despite the four orders of magnitude difference in power between the redshift-zero AGNs, mostly Seyfert galaxies, and that of quasars, they all show a remarkable similarity. The distinction relays on the importance of the so-called blue bump component – emission from the accretion disk – which is absent in Seyfert type 2, mildly present in Seyfert type 1, seen in full realm in quasars. Conversely, the characteristic red bump component – dust reprocessed emission in the IR – is present in all cases. The difference between the three AGN classes can be ascribed in terms of central dust obscuration and progressive view angle of the nuclear core.

1. High spatial resolution SEDs: data source for redshift-zero AGNs

A best estimate of the pure AGN light contribution on very nearby targets has been derived from very high spatial resolution data over a wide range of the electromagnetic spectrum. The compiled SEDs represent the central few tens of parsec region of some of the nearest and brightest AGN. The work is motivated by the current possibility to obtain subarcsec resolution data in the near-to-mid-IR – with adaptive optics and interferometry, and thus at comparable resolutions to those obtained in radio interferometry and the optical-to-UV with HST. The near-to mid-IR high resolution data in this work come mostly from the ESO Very Large Telescope (VLT), hence this study relies on Southern targets, all well known objects, mostly Seyfert galaxies and low luminosity AGN –LINER type. Objects studied in this project include Centaurus A, NGC 1068, Circinus, NGC 1097, NGC 5506, NGC 7582, NGC 3783, NGC 1566 and NGC 7469, Mrk 1239, NGC 1365, MCG -6-30-15, NGC 1052, NGC 3169 and M87.

The main data sources are: VLA and ATCA in their extended configurations in radio, VLT diffraction-limited images and interferometry in the mid-infrared (mid-IR), VLT adaptive-optics images in the near-infrared, and HST imaging and spectra in the optical-ultraviolet. Although X-rays and Gamma-rays do not provide such a fine resolution, information when available above 20 keV are also included in the SEDs on the assumption that above that energy we are mostly sampling the AGN core. Most of the data comes from BeppoSAX and INTEGRAL telescopes. When available, Chandra data extracted from the central 1 arcsec resolution beam is also
Individual SEDs for each of the targets are presented and discussed in [1,3].

2. The spectral energy distribution “template” of redshift zero AGN

The study sample includes different type of AGN: namely Seyfert type 1 and type 2 with a range in power of $10^{42}$ erg/s < Lbol < $10^{44}$ erg/s) and Low Luminosity AGN (LLAGN) with Lbol <$10^{42}$ erg/s. Each of these three classes shows a very specific SED at these high spatial resolutions. To produce genuine SED templates for each type, the best representative examples of each class were selected [1]. By representative it means that intermediate-type-class objects were excluded.

Figure 1a,b presents the resulting SED templates for the Seyfert type 1- and 2-class, indicating as well the targets used to construct them. That derived for LLAGNs is presented in [3] and will not be discussed here. The method used to construct these templates is described in [1]. Briefly, each target SED is normalized to the mean value of its total power, this being derived from integrating its high spatial resolution SED. In doing so, the normalized SEDs result at comparable scale at about the optical-IR region. Then, for each Seyfert type, a median average across the spectrum was produced. The reliability of these templates can be judged by comparing them with the individual SEDs used to construct them, all in each class showing very similar distributions.

Figure 1c shows the Seyfert type 1 and 2 templates plotted on top of each other. There is not further normalization in this plot, note that both averages SEDs show at about the same level in the 10 um region. The two relevant features in both templates is the IR bump and the rising high-energy spectrum.

The IR bump, peaking at about 2 um, can be reconciled with dust emission with an equivalent grey-body temperature of $\sim$300 K [1]. The shape of the bump longward of 2 μm is similar for both Seyfert types; it is shortward of this wavelength where the difference arises: type 2 nuclei are characterized by a sharp decay in power from 2 μm onwards to the optical wavelengths, type 1s present also a decay shortward of 2 μm but this recovers at about 1 μm to give rise to the characteristic blue bump feature seen in Quasars and type 1 sources in general [2]. This dramatic change in the SED suggests a clearer line of sight in type 1s but and obscured one in type 2s. This is in line with the existence of a nuclear parsec-scale torus: the shallower spectrum in type 1s reflects the contribution of much hotter dust from the inner region of the torus which we are able to see directly in this sources; in the type 2s this innermost region remains hidden from our line and we are sampling the enshrouding colder dust only.

The second important feature in the templates is the high energy spectrum. Within the common sampled energy band – 1 to $\sim$100 keV – this region appears rather similar in both AGN types, the general trend being that of a gentle increase in power with increasing frequency.
Figure 1a: average SED of Seyfert type 1 objects and individual SEDs – normalised to their total power – used to construct the average. Filled points on each SED are the original data source.

Figure 1b: same as in figure 1a but for Seyfert type 2s.

Figure 1c: Comparison of Seyfert type 1 and 2 average SED templates (taken from [1]).
3. Comparison with Quasar’s template

Elvis et al [2] constructed the averaged SED template of a sample of radio quiet and of radio loud quasars. Both set of quasars were selected for being strong UV –X-ray emitters. Their average power falls in the $10^{45}$ erg/s range, i.e. about three to four orders of magnitude above than that of the Seyfert’s.

Figure 2 shows the comparison of all the templates: radio loud and radio quiet quasars, Seyfert type 1 and 2. For this comparison, the quasar templates were normalized to their total power integrated over their respective SED in the same manner as done with the Seyfert’s. The resulting normalized SEDs are plotted on top of each other in figure 2. It can be seen that all fall at about the same scale at the location of the IR bump.

Despite the difference in power between the Seyfert and the Quasar class, their respective averaged SEDs show a remarkable resemblance. All are characterized by a strong emission bump in the IR, centered at about the same location over the 2 - 10 μm region, and with comparable width. As in the Seyfert’s case described above, the shape of the bump longward of 2 μm is similar for all types, it being characterized by a smooth fall off towards the radio waves. In the radio loud quasars, the bump starts to depart from the common shape longward of the millimeter region because of their stronger radio emission. Shortward of 2 μm, the difference AGN types start to show their signature:

- The Seyfert type 2 SED is characterized by a sharp decay from 2 μm onwards. Shortward of 1μm, all Seyfert type 2 nuclei are undetected, hence the data gap in their template.
- Seyfert type 1 and quasars, both radio -loud and -quiet, present also a decay shortward of 2 μm but this is progressive: relatively strong in Seyfert type 1, milder in Quasars. The decay ends at a common depression point at about 1 μm – the characteristic inflexion point associated with dust sublimation temperature followed by a rising blue bump emission component. The rise up of this component is also progressive, in this case it is mild in Seyfert 1s but very strong in quasars.

This progressive change in the SED shape as one moves from Seyfert type 2s to quasars can be ascribed to the effect produced by a central -- parsec-scale -- dust obscuration effect in the line of sight. Nuclear dust fully obscures our line of sight to Seyfert 2 cores, produces partial obscuration in type 1s and only in quasars dust is off from our line of sight. This is the well known prediction of the AGN unification models, seen for the first time reflected in the spectral energy distributions of Seyfert and quasars alike.
Figure 2: SED templates for four different AGN types, all normalized to the median of their total power: Seyfert type 2 (red), Seyfert type 1 (blue), radio-loud quasar (dash-line), radio quiet quasar (dots). Seyfert SEDs are from [1], that of quasar’s from [2].

4. Availability of the Seyfert SED templates

Tabular ascii form of the Seyfert type 1 and 2 SED templates are available at http://www.iac.es/proyecto/parsec/main/seyfert-SED-template.php

References
[1] Prieto et al, 2010, MNRAS
[2] Elvis et al. 1994, ApJ
[3] Fernandez-Ontiveros et al. (this proceeding)