An extensive collection of Seyfert 2 galaxy templates

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The need for templates

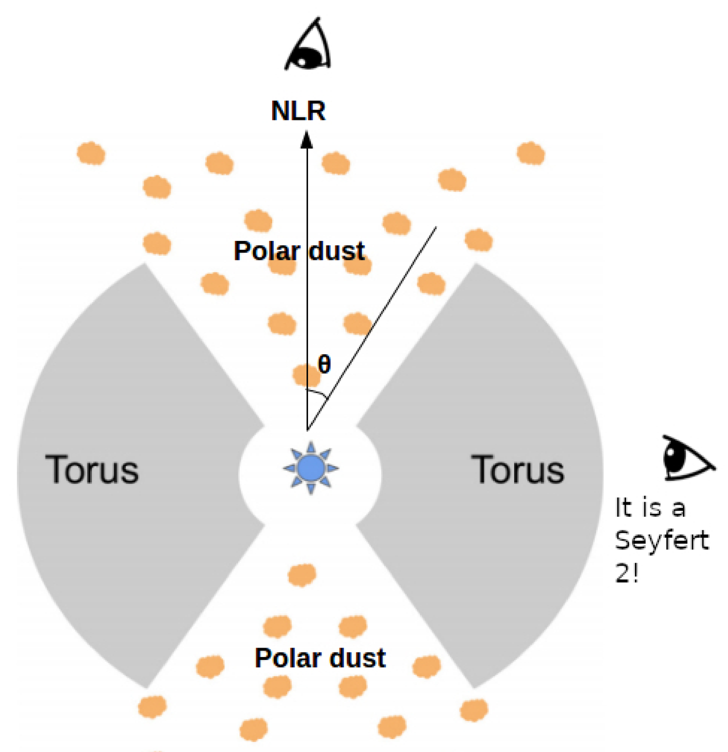
- The physical properties of galaxies are estimated using Population Spectral Synthesis (PSS) codes.
- How do we know whether a PSS code is doing a good job? By performing benchmark tests on a reference grid of galaxy-models.

Our work

- We created an extensive grid of synthetic non-stellar spectral energy distributions for Seyfert 2 narrow-line emission models.
- In addition, we explored the creation of emission-line properties of Active Galactic Nuclei (AGN) through a simple photoionisation model.

Unified model of AGN

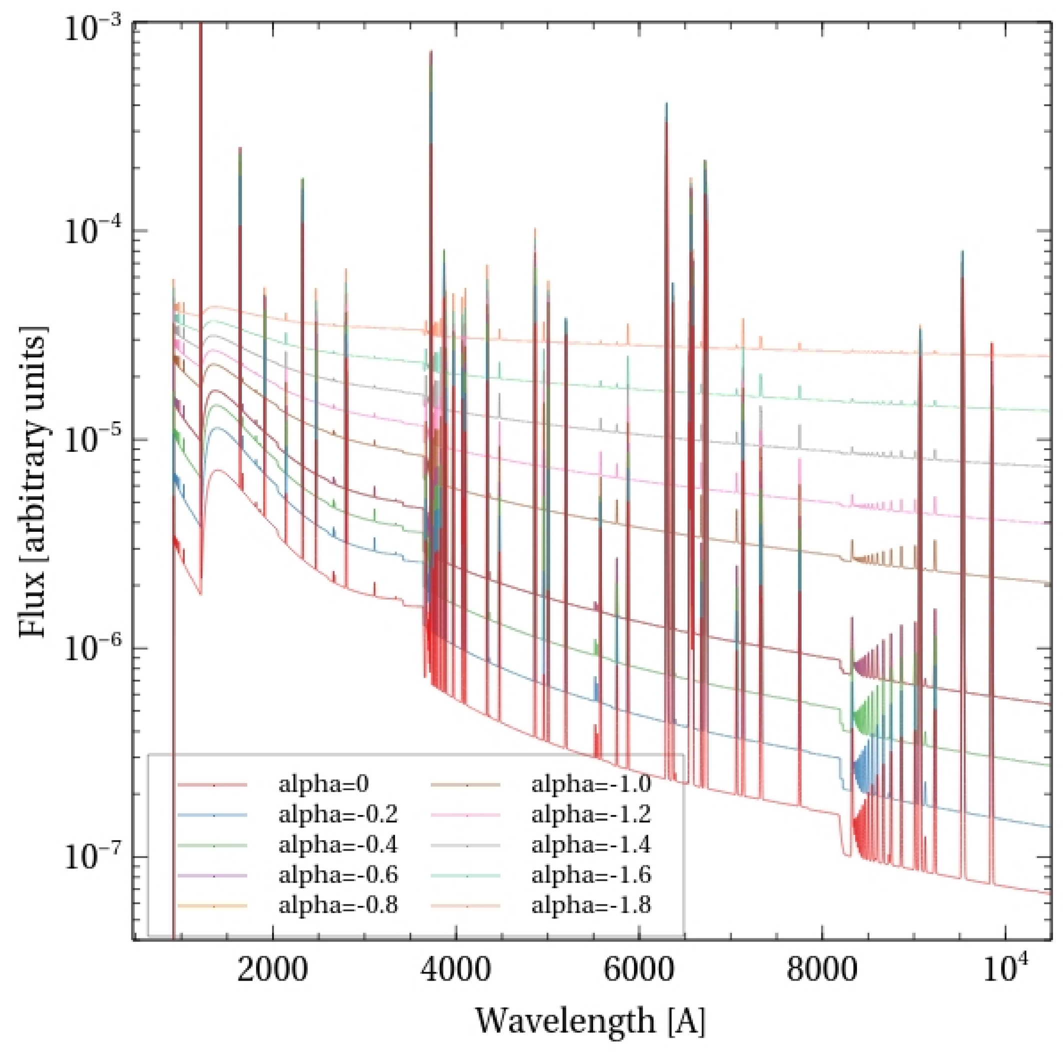
- We have produced our models assuming the unified model of AGN to be true.
- According to the unified model, the viewing angle governs the observed radiation field of an AGN and hence the AGN type: Seyfert 1 and Seyfert 2 when viewed face-on and edge-on, respectively.
- The Narrow Line Region (NLR) as well as the face-on observer sees the direct ionising AGN continuum (after interacting with the polar dust), while the edge-on observer views the processed incident radiation field (as shown in the figure below).



Cross-section of an AGN central engine. The NLR directly sees the central engine and receives the ionising continuum from the accretion disk. The radiation emitted by the central source interacts with the polar dust before reaching the NLR. For an observer viewing a Seyfert 2, the direct view of the central engine is blocked by the dusty torus. Hence, he cannot observe the ionising AGN continuum directly but the processed radiation field. Source: Yang et al., 2019 (modified by Abhishek Chougule).

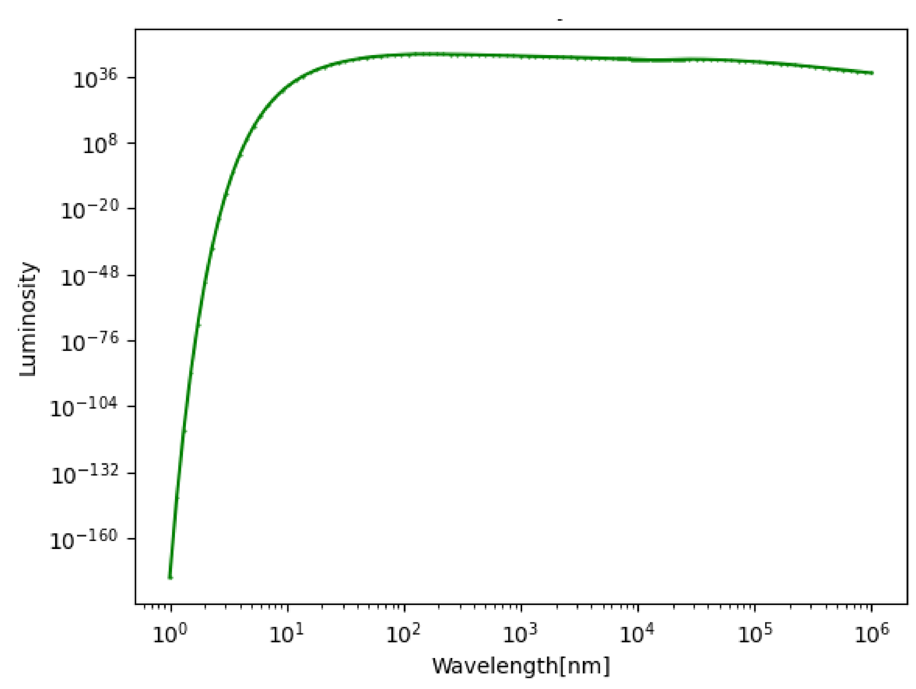
Single power-law templates

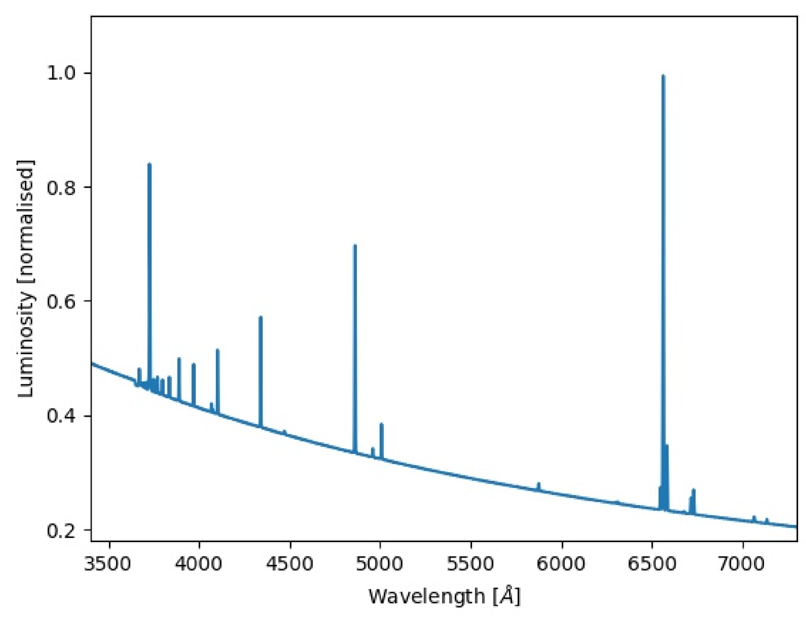
- What is a power law? A function: $f_\nu \propto \nu^\alpha$; α is the power-law index and ν is the frequency.
- Single power-law models: same, fixed value of alpha represents the ionising and underlying continuum for the entire wavelength/frequency range.
- We have created such a set of Seyfert 2 models having various ranges in the parameters.
- Index power-laws going from -2.0 to +1.0, Hydrogen number densities from 10^0 to $10^6\,\mathrm{cm}^{-3}$ and six different solar metallicities.
- We have generated a total number of the order of 30000 models.
- Approximately 15% of these models are compatible with observed Seyfert 2 properties in the local universe.



An example of our single power-law Seyfert 2 models having different power-law indices. The gas-density, log(n) = 2, and the emission line broadening = 150 km/sec. The effect of spectral index on the line strengths and the overall spectral shape can be clearly seen

Towards the production of more realistic templates



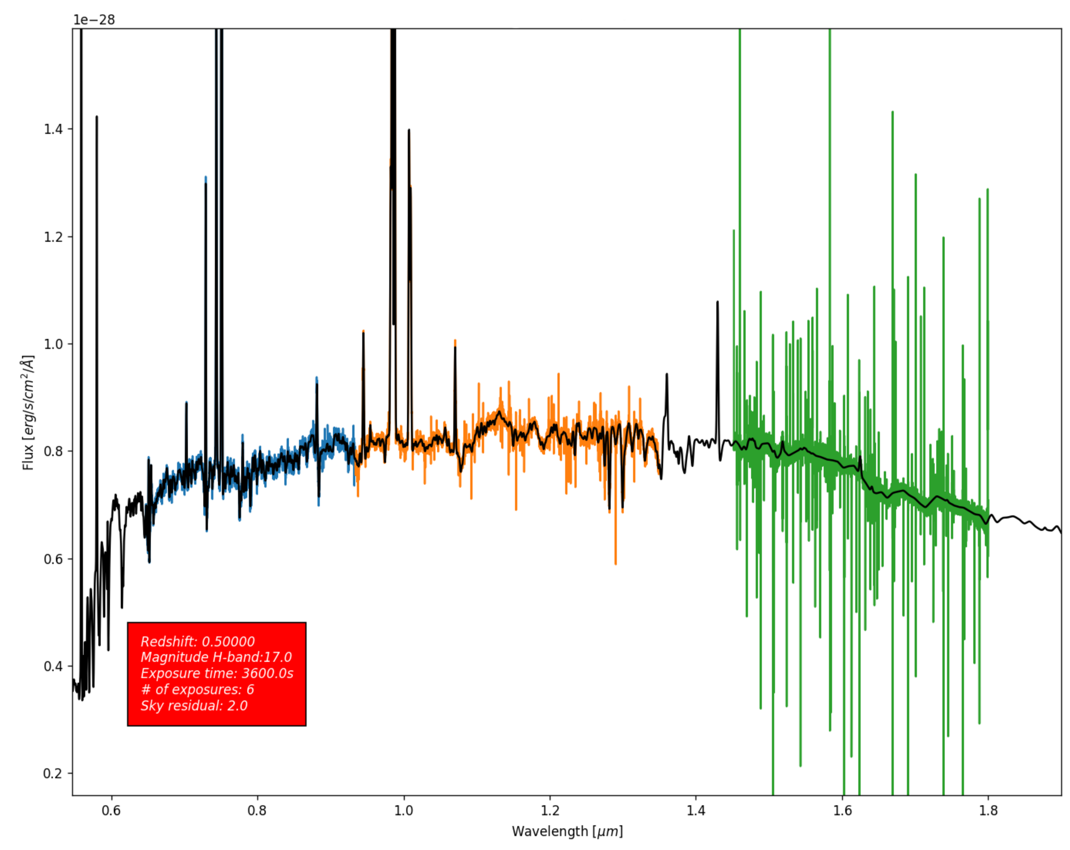


An example of realistic radiation field and template. Top: radiation field incident on the NLR. This field is used to calculate the NLR emission lines. **Bottom:** The final template obtained by combining the realistic continuum radiation field with the emission lines.

- We have also created a reference grid of Seyfert 2 narrow-line emission models using more realistic incident radiation field models.
- Using SKIRTOR[1,2] models for incident radiation field, we have produced models with emission lines, which are calculated self-consistently.
- The SKIRTOR models have been calculated for AGNs having a two-phase medium dust distribution in the torus–a large number of high-density clumps embedded in a smooth dusty component of low density.
- We account for the anisotropy of the accretion disk due to its projected area and limb darkening effect. We also include the effects of polar dust extinction and re-emission in our models.
- This approach led to the development of a standalone AGN module primarily built from scratch in Python3.
- The module, depending on the viewing angle and other AGN properties, permits the computation of a realistic continuum radiation field for AGN (see the previous figure).
- Furthermore, this module, combined with a photoionisation code, allows us to evaluate the corresponding emission lines (see the previous figure).

VLT/MOONS galaxy simulations: a plethora of models across distinct redshifts slices

- We have used our models to generate realistic VLT/MOON observations of AGN from redshifts 0.5 to 2.5 using an in-house developed pre- plus post-processing pipeline.
- A total of 6 million mock observations were created just for the single power-law models.
- This study is beneficial to interpret observations of intermediate-redshift galaxies from the VLT/MOONS facility. For example, based on these simulations, we will be able to decide how long MOONS should look at a specific galaxy to collect data from it with the desired maximum quality.



VLT-MOONS simulated spectra of an AGN at redshift 0.5 with an H-band magnitude of 17. The simulation corresponds to an exposure time of 1 hour, 6 exposures and a sky residual of 2%.

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[1]Stalevski, Marko et al. (Mar. 2016). "The dust covering factor in active galactic nuclei". In: Monthly Notices of the Royal Astronomical Society 458.3, pp. 2288–2302.
[2]Stalevski, Marko et al. (Mar. 2012). "3D radiative transfer modelling of the dusty tori around active galactic nuclei as a clumpy two-phase medium". In: Monthly Notices of the Royal Astronomical Society 420.4, pp. 2756–2772.