Torus properties in intermediate type AGN

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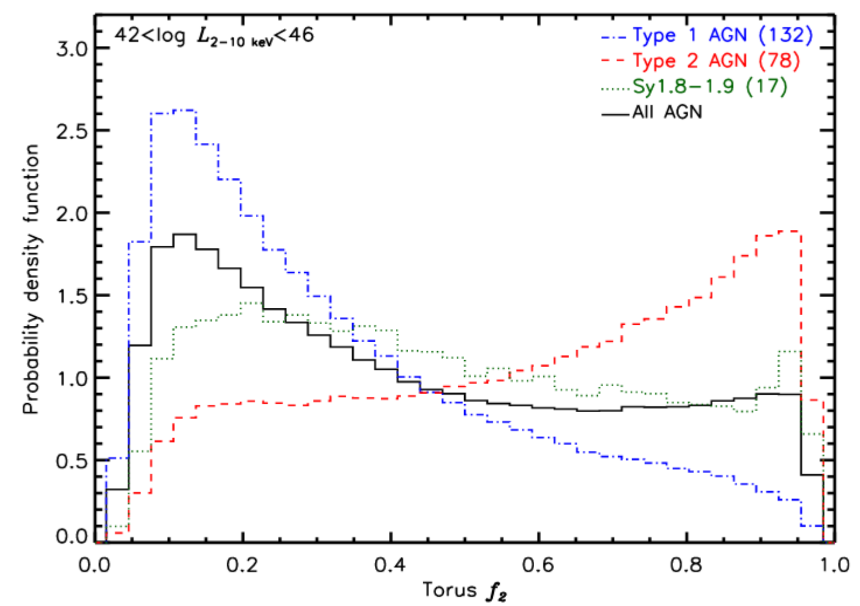
Summary

The geometrical covering factor (f_2) of the AGN nuclear absorber, the so-called "dusty torus", is substantially larger in optical type 2 AGN than in type 1 objects. We have investigated whether we observe the same effect for type 1 objects with increasing subtypes, from 1 to 1.9 to shed light onto the physical origin of the intermediate type classification of AGN: partial obscuration or an intrinsically weaker Broad Line Region at low AGN luminosities. Using a sample of 123 type 1 AGN with intermediate classification we have found that type 1.0, 1.2 and 1.5 AGN have similar distributions of f_2 while objects classified as 1.8 and 1.9 have f_2 values halfway between those of AGN types 1.0/1.2/1.5 and type 2s.

Context of the work

- Previous works have shown that the **geometrical covering factor of the AGN nuclear absorber**, the so-called "dusty torus", defined as the fraction of sky obscured (hereafter f_2) **is larger in obscured type 2 AGN than in unobscured type 1 AGN** (Ramos-Almeida+11,Alonso-Herrero+11,Ichikawa+15, Mateos+16, García-Bernete+19).

Mateos+16



- **Type 1 are subclassified** into 1.0, 1.2, 1.5, 1.8 and 1.9 **according to the flux ratio R** between the narrow emission line [OIII] at 5007 Å and the broad emission line H_β (e. g. Whittle+92).

$$\mathbf{R} = \frac{F_{[\mathrm{OIII}]}}{F_{\mathrm{H}\beta}}$$

- R<0.3 → 1.0
- R<1 → 1.2
- R<4 → 1.5
- R>4 → 1.8
- No broad H_β, Broad H_α present → 1.9

- The physical difference between intermediate types has been assumed to be due to an increasing nuclear partial obscuration by the torus or alternatively to an intrinsically weaker Broad Line Region (BLR) in low luminosity AGN. To shed light onto this issue, we studied the distribution of f_2 of a sample of 123 type 1 AGN with intermediate classification.

Methodology

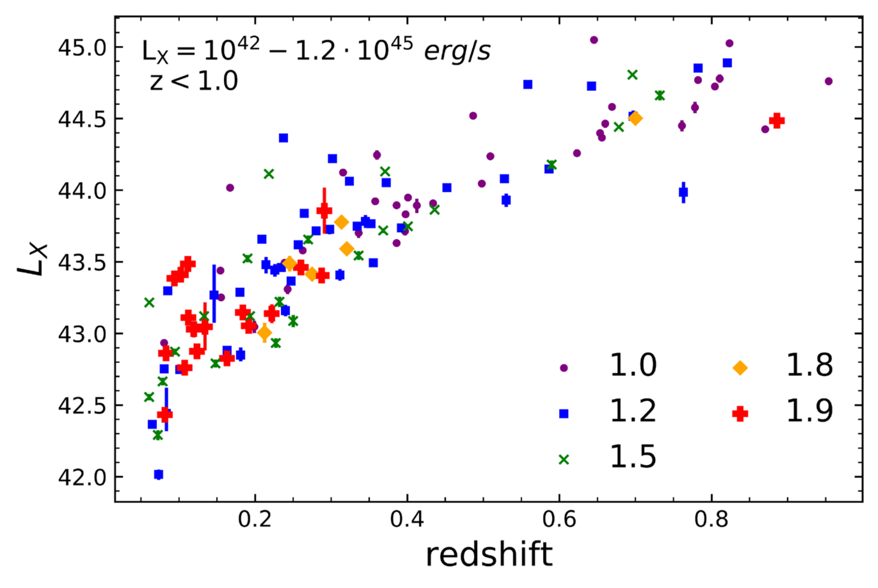
We use a **sample of 123 type 1 AGN** drawn from the BUXS survey, a flux-limited sample of 259 non-BLAZAR AGN detected from 4.5 to 10 keV energies with XMM-Newton (Mateos+16). **Our AGN have intermediate classification** derived from optical spectra (Ordovás-Pascual, in preparation) and rest-frame UV-to-mid-infrared photometric spectral energy distributions that we use to reveal the emission from the AGN tori.

To determine f_2, we need first to isolate the emission from the torus. To do so we follow two-step process:

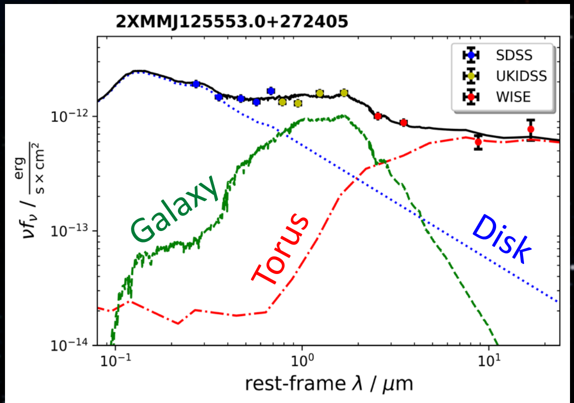
1. **AGN-host decomposition: we fit the UV-to-MIR SEDs of our sources with templates** reproducing the emission from the accretion disk, the torus and the AGN hosts using the software SEABAS (Rovilo+14). Then, **we isolated the torus emission** at rest-frame wavelengths >1 μm.

2. **Modelling of torus SEDs:** using Nenkova+09 models and BayesCLUMPY software (Asensio-Ramos & Ramos-Almeida+09) **we fit the torus SED and recover different parameters of the torus, including the f_2 distribution.**

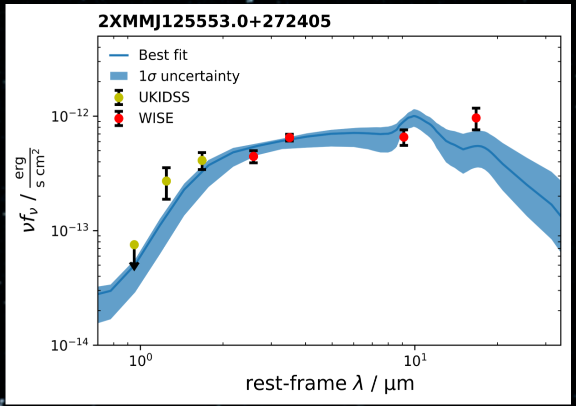
X-ray luminosity vs redshift distribution of the sample



Step 1: AGN-host decomposition

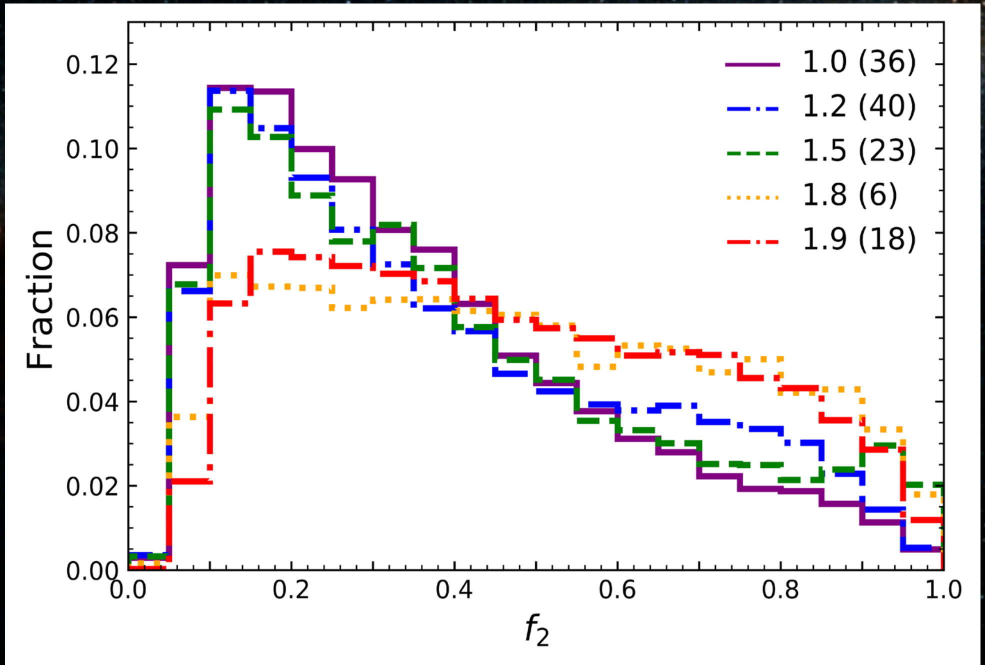


Step 2: torus SED fit



Results: Dependence on intermediate classification

- By applying a Kolmogorov-Smirnov (KS) test we find that the significance of the difference of f_2 between 1.0, 1.2 and 1.5 is less than 1σ.
- We found the same results when comparing distributions of 1.8 and 1.9 AGN.
- On the other hand, we do find that the f_2 distributions for types 1.5 and 1.8 are different at a significance level greater than 1σ.



- The distributions of X-ray luminosities (a tracer of the AGN accreting power) for the different AGN subtypes are very similar. Hence, it is unlikely that an intrinsically weak BLR alone can explain their optical class.

There are no appreciable changes in the f_2 shape between 1.0, 1.2, and 1.5 AGN.

The distribution of f_2 for 1.8 and 1.9 AGN changeto a flatter distribution with higher f_2 values.

Results: Dependency on intermediate classification

THE low significance of our results MIGHT be due to the small size of our samples. To overcome this issue we grouped 1.2 and 1.5, and 1.8 and 1.9. Then we run again the KS test.

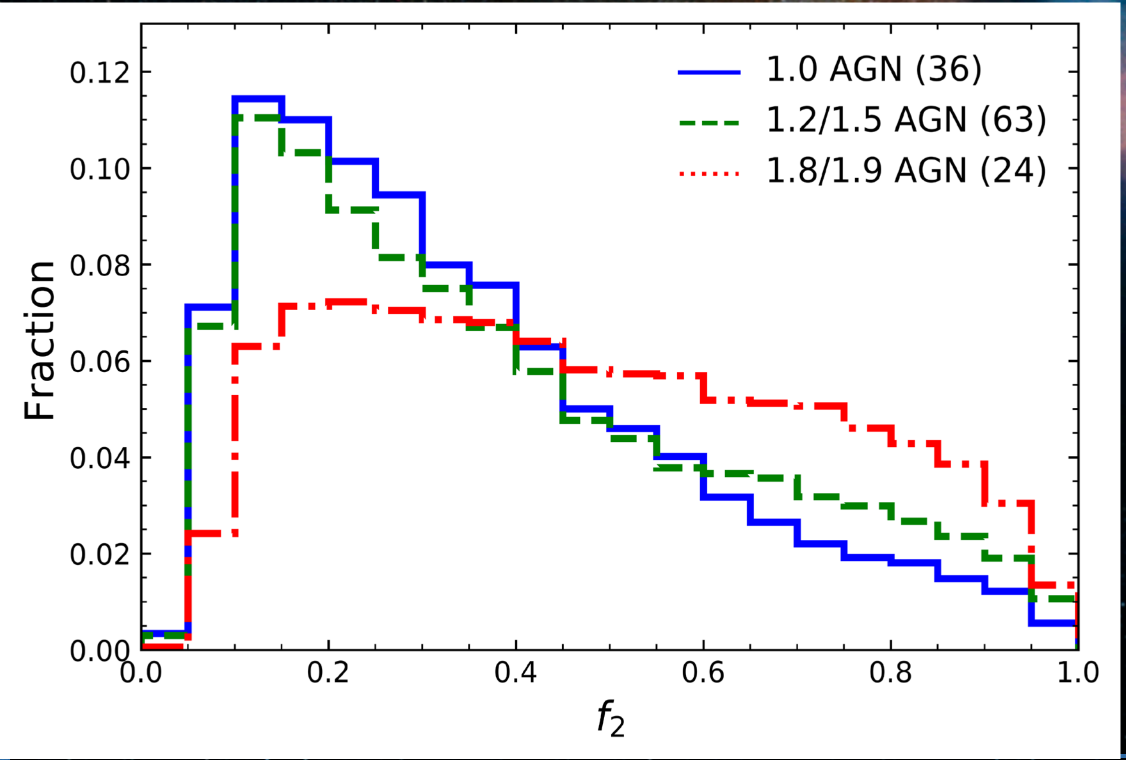
1.0 vs 1.2/1.5 —— $< 1\sigma$

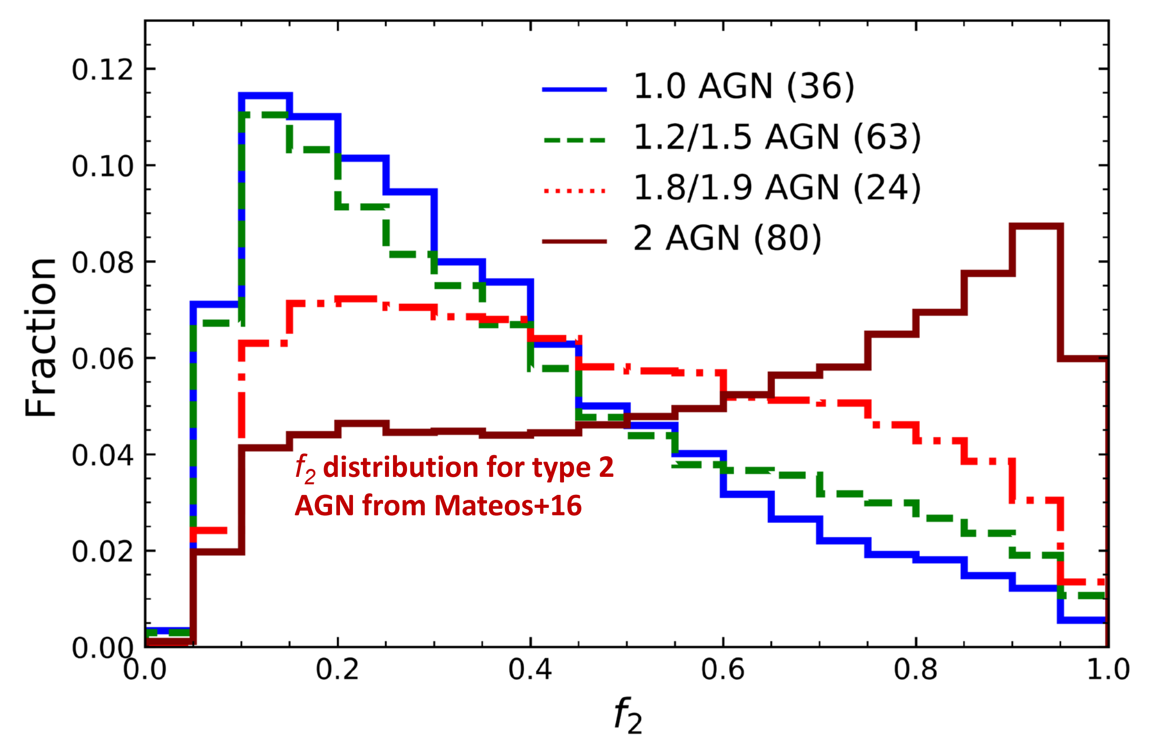
1.2/1.5 vs 1.8/1.9 —— $> 2\sigma$

1.0/1.2/1.5 type and 1.8/1.9 type f_2 distributions are different: 1.8/1.9 AGN have tori with larger covering factors overal.

1.8/1.9 vs 2 —— $\sim 3\sigma$

1.8/1.9 and type 2 AGN have tori with different covering factors.





Conclusions

- **There is a change of the overall f_2 distribution from lower to higher values with increasing AGN subtype**. The evolution is not gradual but in form of steps.

- **Type 1.0/1.2/1.5 are intrinsically the same type of objects according to their torus properties**. Their different optical spectra may be due to to an increasing level of extinction associated to material in their hosts. It is unlikely that an intrinsically weak BLR alone can explain their optical class according to their distributions of X-ray luminosities .

- **We find that the type 1.8/1.9 classification is mostly associated to an increase level of nuclear obscuration.** This result is supported by the higher X-ray absorption fraction (~72% in type 1.8/1.9 versus ~10% in types 1.0/1.2/1.5) found for this sample (Ordovás et al. in prep.).

- **Type 1.8/1.9 are also intrinsically different from type 2 AGN**. Thus, caution must be taken when including these objects in type 2 AGN samples.