X-ray spectral variability of LINERs selected from the Palomar sample*

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1. Introduction & Aims

Active galactic nuclei (AGN) are divided in type 1 (broad permitted lines) and 2 (narrow lines) at optical wavelenghts. From the viewpoint of the unified model (UM) of AGN (Antonucci 1993) the differences are due to orientation effects relative to a dusty torus surrounding the nuclear black hole. Low luminosity nuclear emission line regions (LINERs) are usually seen as scaled-down versions of Seyfert galaxies, but the way to introduce them within the UM is still controversial (Ho 2008). Although variability is a general property of AGN (Peterson 1997), how these changes occur is not yet clear. The first evidence of the variable nature of LINERs was the work done by Maoz et al. (2005). Variations have been found for some objects at X-rays (Younes et al. 2011, Hernández-García et al. 2013), but the main driver of the changes is still an open question.

The main purpose of this work is to investigate the X-ray variability in LINERs, including the main driver of such variations, and to search for eventual differences between type 1 and 2 LINERs.

2. Data & Methodology

We use 18 LINERs from the Palomar Sample (Ho et al. 1997) with data from *Chandra* and/or *XMM*-Newton archives at different epochs. The galaxies are divided in two groups: **AGN candidates** (point-like source at hard X-rays) and **non-AGN candidates** (otherwise, see Table 1) (González-Martín et al. 2009).

All the spectra from the same object are simultaneously fitted (see Fig. 1) to study long term variations. The nature of the variability patterns are studied allowing different parameters to vary during the spectral fit.

Short term variations are studied from the analysis of the light curves, and UV variations when data are available from the optical monitor onboard *XMM*-Newton (see Fig. 2).

3. Results

See Table 1, with the same color code:

- **No short term variations** are reported in X-rays.
- The **three** LINERs classified as **non-AGN in X-rays do not show variations** at those frequencies, all are Compton-thick candidates (i.e., $N_H > 1.5 \times 10^{24}$ cm^{-2}) and **two of them show UV variations**.
- **Long term X-ray variations can be analysed in 12** out of the 15 **AGN candidates**, **seven** of them **showing variability**. At **UV** frequencies, **five out of six** AGN candidates with available data are variable.
- **13 AGN candidates are analysed at UV and/or X-rays, 10 of them variable at least in one energy band. Therefore, long timescale variability is very common in LINERs.**
- The main driver of these X-ray variations is related to **changes in the nuclear power**, while changes in absorption are found only in the case of NGC 1052. We do not find **any difference between type 1 and 2 LINERs**, either in the number of variable cases (three out of five type 1s and four out of seven type 2s) nor in the nature of the variability pattern.
- McHardy et al. (2006) reported a relation between the bend timescale for variations, T_B, black hole mass and bolometric luminosity. Fig. 3 show it vs. the shortest period where variations were observed, T_{obs}. All the variable objects in our sample are consistent with this relation, under which LINERs would have the same emission mechanism than other AGN.
- The accretion in LINERs is though to be dominated by radiatively inefficient accretion flows. An indication would be the anticorrelation between Γ and the Eddington ratio. We can not conclude such relation based in this set of data (Fig. 4).

Name	Morph. Type	Optical class.	X-ray class.	Flux variability X-rays	Flux variability UV
NGC 315	E	L1.9	AGN	0%	No data
NGC 1052	E	L1.9	AGN	20%	21%
NGC 1961	SAB(rs)c	L2	AGN	0%	No data
NGC 2681	S0-a(s)	L1.9	AGN	0%	No data
NGC 2787	S0-a(sr)	L1.9	AGN	-	No data
NGC 2841	Sb(r)	L2	AGN	-	No data
NGC 3226	E	L1.9	AGN	-	11%
NGC 3608	E	L2/S2:	Non-AGN	0%	No data
NGC 3718	SB(s)a	L1.9	AGN	29%	No data
NGC 4261	E	L2	AGN	0%	34%
NGC 4278	E	L1.9	AGN	29%	No data
NGC 4374	E	L2	AGN	71%	No data
NGC 4494	E	L2::	AGN	35%	No data
NGC 4636	E	L1.9	Non-AGN	0%	28%
NGC 4736	Sab(r)	L2	AGN	0%	66%
NGC 5195	IA	L2:	AGN	19%	16%
NGC 5813	E	L2:	Non-AGN	0%	8%
NGC 5982	E	L2::	AGN	49%	0%

Table 1. Properties and results of the sample galaxies.

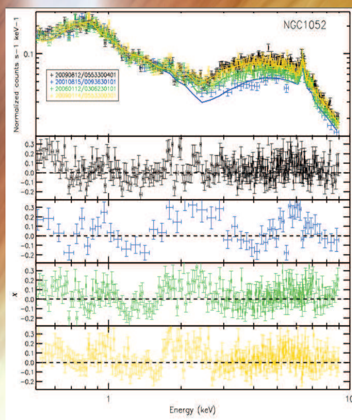

Figure 1. Simultaneous spectral fit of NGC 1052 in four different dates and the residuals of each observation.

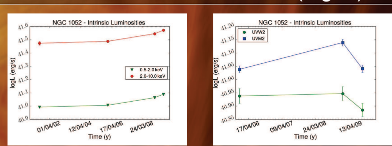

Figure 2. Left: X-ray luminosities in the 0.5-2 keV (green) and 2-10 keV (red) energy bands. Right: UV luminosities in the UVW2 (green) and UVM2 (blue) filters of NGC 1052.

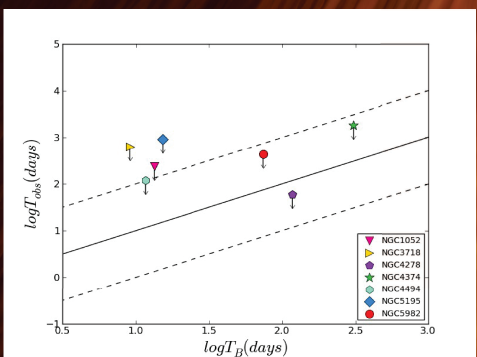

Figure 3. Observed variability timescale, T_{obs}, against the predicted value, T_B. The solid line represents the 1:1 relation, and the dashed lines take into account the errors in the observables.

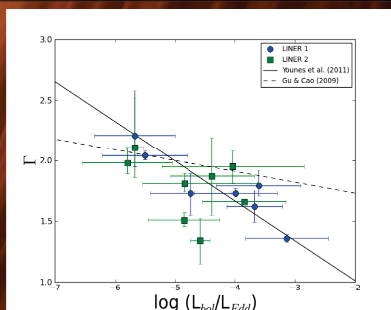

Figure 4. Slope of the power-law, Γ, vs. The Eddington ratio for the type 1 and 2 LINERS in our sample.

4. Conclusions

We found that **X-ray variations are due to changes in the continuum of the AGN**. These results agree well with the expected variations according to their BH masses and accretion rates. Thus, **LINERs behave as more powerful AGN in X-rays. We can not conclude if a different accretion mechanism operates in LINERs.**

On the other hand, the result that **some type 2 LINERs vary at UV frequencies** may suggest that a naked AGN can be observed at these wavelengths, what could be explained in the scenario where the **torus dissapears** at low luminosities.

5. References

Antonucci 1993, ARA&A, 31, 473
González-Martín et al. 2009, A&A, 506, 1107
Hernández-García et al. 2013, A&A, 556, A47
Ho et al. 1997, ApJS, 112, 391
Ho 2008.ARA&A, 46, 475
Maoz et al. 2005, ApJ, 625, 699
McHardy et al. 2006, Nature, 444, 730
Peterson 1997, An Introduction to AGN, ed. Peterson, B.M.
Younes et al. 2011, A&A, 530, A149

*** Hernández-García et al. 2014 (submitted)**