Nature of the soft X-ray emission found in LINERs

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Introduction:

**LINER definition:** “Optical spectrum dominated by emission lines of low ionization states.”

Many questions have been discussed...

- Which is the emission mechanism?
- Are they an evolutionary link between active and inactive nuclei?
- How the fit under de Unified scenario?
- ...
Sample:

Comprise 82 LINERs observed with XMM-Newton or/and Chandra coming from:

“All the LINERs compiled by Carrillo et al. 1999 identified in the literature as LINERs and reclassified following the BPT diagrams.”

- We have extracted EPIC/pn and ACIS images (82) and low resolution spectra (60/82)
- We have extracted RGS spectra of LINERs (52/82)
LINERs: > 80% AGN (adding multiwav.)


O. Gonzalez-Martin, Bologna 2009
Current Theoretical Model

NGC4261 - 0056340101

Thermal model

Soft power-law

Hard power-law

FeK

Photons cm\(^{-2}\) s\(^{-1}\) keV\(^{-1}\)

Energy (keV)
Similarities
Similar X-ray spectrum:

![Graph showing thermal model, soft power-law, and hard power-law](image)
Similar X-ray spectrum:

Current Theoretical Model

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NGC 4261 - 0056340101

Photons cm$^{-2}$ s$^{-1}$ keV$^{-1}$

Energy (keV)

FeK

13 objects

13 objects
Compton-thin LINERs
- Compton-thick LINERs
- Compton-thin Seyferts 2
- Compton-thick Seyferts 2
- Seyferts 1
- QSOs

LINERs: ~ Luminosities overlap with Seyfert 2

All ($r = 0.92$)
LINERs ($r = 0.86$)

Differencies
LINERs: ~ 50% Compton-thick

Compton-thick LINERs show low EW(FeKα)
Strong thermal component

$\sim 0.7$ keV
($> 50\%$ below 2 keV)
Strong soft component:

High resolution spectra with RGS/XMM-Newton

(Working progress)
Soft X-ray emission in Seyferts:

The soft X-ray emission is identified as photoionization by the nucleus.

- **Morphology**: It overlaps with the [OIII] emission coming from the NLR.  
  (Bianchi et al. 2006)

- **Spectroscopy**: High resolution spectra of Seyferts shows that the photoionization by the nucleus is the responsible for the X-ray soft emission with a contribution of photoexcitation.  
  (Guainazzi & Bianchi 2007)

The spectral clues of the emission nature through the high resolution spectroscopy are:

- Supporting photoionization by the nucleus, the spectrum presents narrow radiative recombination continua (RRC) features of OVIII, OVII and CV.
- The intensity of higher order transitions are enhanced with respect to the Ka than predicted for pure photoionization.
Soft X-ray emission in LINERs:

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Gonzalez-Martin et al. 2010, in prep.
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![Graph showing the FeXVII triplet can contaminate the OVII RRC](image)

O. Gonzalez-Martin, Bologna 2009
Soft X-ray emission related to star-formation?

- $\text{wabs(apec\{kT\})}$ ................................................................. 12
- $\text{wabs(apec\{kT1\}+apec\{kT2\})}$ ................................................................. 2
- $\text{wabs(apec\{kT1\}+apec\{kT2\}+apec\{kT3\})}$ ........................................... 0
- $\text{wabs(apec\{kT1\}+apec\{kT2\}+apec\{kT3\}+apec\{kT4\})}$ ...................... 0
- $\text{wabs(apec\{kT, Abundance\})}$ ................................................................. 10

We are now testing CLOUDY models to simulate the pure photoionization scenario.
Summary

- LINERs are similar to type 2 Seyferts: (1) same range of luminosities and (2) same overall X-ray spectrum.

- LINERs are different to type 2 Seyferts: (1) The strong soft component; (2) higher proportion of Compton-thick sources and (3) the low EW(FeKa) of Compton-thick LINERs.

- The soft X-ray emission in LINERs seems to be associated with photoionization by the nucleus, as type 2 Seyferts. However, the lack of enough statistics prevent us to make any strong conclusion.

- Although the low statistic is affecting the results, this soft X-ray spectrum can be fitted with an APEC, letting free the temperature and the abundance in 22 out of the 52 objects (42%). We are testing CLOUDY models.
To be continued...