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X-Ray Nature of the LINER Nuclear Sources

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Abstract. We have investigated the nature of the energy source of 36 LINERs with Chandra X-ray observations selected from the catalogue by Carrillo et al. (1999). In most galaxies a nuclear compact source has been detected in the hard band (2-8 KeV). However they show a rather irregular morphology embedded in diffuse X-ray emission for lower energies (0.3-2 KeV). In this work we report the spectral analysis of the nuclear source. Color-color diagrams allow us to determine the dominant mechanism in them. Synthetic colors have been computed for a power-law , thermal emission and a combination of both. The results suggest a non thermal nature in most of the LINER galaxies observed.

Key words. AGN – Chandra – X-Ray – LINER

1. Introduction

There is still an ongoing strong debate on the origin of the energy source in LINERs. Two alternatives have been explored: that the ionizing energy source is a low luminosity AGN Filippenko & Halpern, (1984), or that this energy is of thermal origin from massive star formation (1992) and/or from shock heating mechanisms resulting from the massive stars evolution (1978), (1976). The search of a compact X ray nucleus in LINERs is indeed one of the most convincing evidences about their AGN nature. Chandra's excellent resolution allows an investigation of the X-ray nuclear properties of these galaxies.

We have searched in the Chandra Archive for all the galaxies from the compilation by (1999). This amounts to 65 out of 476 LINERs for which ACIS-S imaging data are available. In this paper we report the results obtained for 36 of them, those with a high count rate. Soft (0.3-1.0 KeV), medium (1-2 KeV) and hard (2-8 KeV) bands have been defined and color-color diagrams have been built as a first attempt to classify the nuclear source for data with low count rate.

2. Results

2.1. Nuclear Classification

We have classified the nuclear morphology attending to the compactness in the hard (5.0-8.0 Kev) band. Therefore the sample has been grouped mainly into 2 categories:

- **AGN-like nuclei**: We include all the galaxies with a clearly identified unresolved nuclear source in the 5.0-8.0 KeV band. 16 out of the 36 galaxies fits into this criterion (45% of the objects).
- **Starburst-like nuclei (SBs)**: Here we include all the objects without a clear nuclear

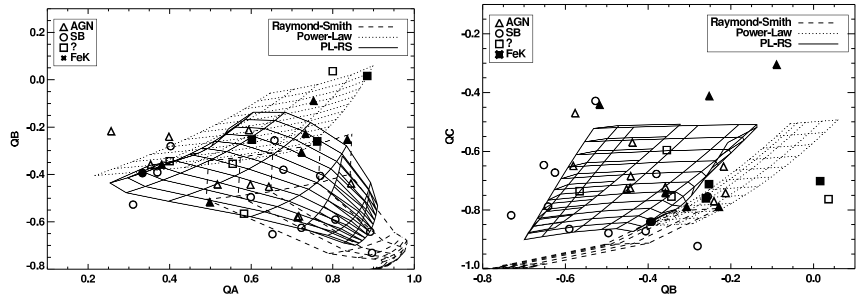

Fig. 1. (a) Left: Q_B versus Q_A diagram. (b) Right: Q_C versus Q_B diagram. Different tracks for the model consider column densities from 10^{20} to $30 \cdot 10^{20}$. Spectral indices for a Power–Law models go from 0.4 to 2.6. Temperatures for Raymond–Smith go from 0.4 to 4.0 KeV.

source in the hard band. 13 out of the 36 galaxies are found (36%).

The remaining 7 galaxies (19%) can not be classified because they have different components near the nuclei. Further analysis at optical and radio frequencies are needed to determine the nature of their nuclear source.

2.2. Computation of the X-Ray Luminosity

Since most of our objects show a clear compact nuclear source, large departures from a power law index of 1.8 are not expected (2004). Hence, X-ray luminosities in the hard band have been first calculated following (2001), who assume a power law with a spectral index of 1.8 for the SED. Nevertheless, this approach has been shown to be too simplistic in some cases (i.e. NGC 3077 (2003)). Therefore a careful analysis of the SED has been performed in order to get better estimations of the luminosities. A two component model has been formally fit to each spectrum, using an absorbed Raymond-Smith model for the thermal contribution and an absorbed Power-Law model. The calculated luminosities between 2-10 KeV show large differences between objects classified as AGN-like with a median value of $5x10^{39}$ erg/s and SBs with a median value of $5x10^{37}$ erg/s. Greatest column densities have been obtained for the unclassified objects. This can explain the lack of clear classification.

2.3. Color-Color Diagrams

We have computed the theoretical color-color diagrams (Fig. 1). The models used are: (1) Power-Law model to fit an AGN spectrum (dotted lines), (2) Raymond-Smith model to fit a thermal spectrum (dashed lines) and (3) A combination of both (full lines). In Fig. 1a SBs mostly occupy the region of the thermal models. In Fig. 1b however the AGN-like are located in the region defined by mixed models. The galaxies with Fe-K detection have been marked with stars. It has to be noticed that most of them have been classified as AGN and are located in the power-law tracks.

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