

X-Ray Observations of Low-Luminosity Active Galactic Nuclei

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Abstract. Through X-ray observations with *ASCA*, low-luminosity active galactic nuclei have been found in at least seven near-by spiral galaxies. Some of them exhibit very intense, and possibly broad, Fe-K emission lines. Their time variability is relatively insignificant, in contrast to low-luminosity Seyfert galaxies.

1. Introduction and Summary

X-ray searches for low-luminosity AGNs (LLAGNs), hidden in nearby apparently normal galaxies, provide a powerful way of studying the relationship between normal galaxies and AGNs. Our investigations using the *ASCA* Observatory suggest that the LLAGNs are indeed quite numerous, particularly among LINERS. They are in some respects similar, but in other respects dissimilar, to Seyferts.

2. Observation and Results

We observed seven LLAGN candidates (Table 1) with *ASCA*. They have been selected based on their LINER properties, or evidence for optical/radio jets.

Table 2 summarizes the results of our study. In all targets, the presence of LLAGNs has been established based on the relatively large X-ray luminosities and hard power-law continua, sometimes augmented by the detection of Fe-K lines. Thus, LLAGNs appear to be quite numerous, particularly among LINERS.

Among these LLAGNs, by far the most impressive case is M106 (NGC 4258), in which a mass concentration of $3.6 \times 10^7 M_{\odot}$ at the nucleus have been revealed with the water maser measurements [6]. This, in combination with our X-ray luminosity [5], implies that the M106 nucleus is emitting at $\sim 10^{-5}$ times the Eddington luminosity. Therefore, the M106 nucleus is a genuine LLAGN. We speculate that other objects are under similar conditions.

We did not detect noticeable short-term variability from LLAGNs (except M81 [1]); hence we suggest that LLAGNs have rather large black-hole masses. Furthermore, the Fe-K lines from LLAGNs may exhibit systematically higher energies than 6.4 keV, and those from M81 and NGC 1365 may be intrinsically

Table 1. Log of *ASCA* Observations of Low-Luminosity AGNs

| Galaxy name | Type | Distance (Mpc) | Special features | Date of observation | Ref. |
|---------------|------|----------------|-----------------------|------------------------|-------|
| M51 (N 5194) | Sbc | 9.6 | LINER, radio nuc. | 1993 May 11 | [4,8] |
| M81 (N 3031) | Sab | 3.6 | LINER, radio nuc. | 1993–1995 ^a | [1] |
| M104 (N 4594) | Sap | 17.5 | LINER. | 1994 Jan 20 | [7,8] |
| M106 (N 4258) | Sbc | 7 | radio/H α jets | 1993 May 15 | [5,8] |
| NGC 1097 | SBbc | 24 | optical jets | 1994 Jan 12 | [2] |
| NGC 1365 | SBb | 20 | LINER, hot spots | 1995 Jan 25 | [3] |
| NGC 1386 | S0 | 20 | Seyfert 2 | 1995 Jan 26 | [3] |

^aObserved 11 times (together with SN1993J) from 1993 April through 1995 October.

broad. These subtle differences suggest that LLAGNs are genetically distinct from Seyferts, LLAGNs having a closer connection to the past quasars.

Table 2. Results of *ASCA* Observations of Low-Luminosity AGNs

| Galaxy name | L_x (10^{40} ergs s $^{-1}$) | Absorption (10^{21} cm $^{-2}$) | Photon index | Fe-K <i>EW</i> (keV) | Fe-K energy (keV) |
|-------------|------------------------------------|-------------------------------------|-----------------|----------------------|-------------------|
| M51 | 1 | < 20 | 1.6 ± 0.2 | | |
| M81 | 2 | 1.7 ± 0.5 | 1.87 ± 0.05 | 0.17 ± 0.05 | 6.65 ± 0.06 |
| M104 | 8 | 4 ± 1 | 1.8 ± 0.2 | | |
| M106 | 4 | 150 ± 20 | 1.78 ± 0.29 | 0.25 ± 0.10 | 6.5 ± 0.2 |
| N1097 | 10 | 1.3 ± 0.4 | 1.79 ± 0.04 | < 0.30 | |
| N1365 | 3 | < 15 | 0.9 ± 0.3 | 2.1 ± 0.9 | 6.62 ± 0.10 |
| N1386 | 5 | 500 ± 300 | 2.1 ± 0.5 | 1.8 ± 1.2 | 6.55 ± 0.08 |

References

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