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X-ray Emission from Supermassive Black Holes in Elliptical Galaxies and Low Radiative-efficiency Accretion

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Abstract. We discuss the detection of hard, power-law emission components in the X-ray spectra of six nearby, giant elliptical galaxies observed with the ASCA satellite and its implication for low-radiative efficiency accretion models around the central, supermassive black holes.

1. Hard, Power-law X-ray Emission from Elliptical Galaxies

The nuclei of elliptical galaxies provide the cleanest environments for studying the physics of low-luminosity accretion. Here, we report the detection of hard, power-law emission components in the X-ray spectra of six nearby, giant elliptical galaxies observed with the ASCA satellite (Allen, Di Matteo, & Fabian 2000). The giant ellipticals studied, which exhibit strong, dynamical evidence for supermassive black holes in their nuclei, are M87, NGC 1399, NGC 4696 NGC 4472, NGC 4636, and NGC 4649. The ASCA data for all six sources provide clear evidence for hard, power-law emission components with photon indices in the range $\Gamma = 0.6$–1.5 and intrinsic 1–10 keV luminosities of 2×10^{40}–2×10^{42} erg s^{-1} (as summarized in Figure 1; Allen et al. 2000). This potentially new class of accreting X-ray source has X-ray spectra significantly harder than Seyfert nuclei and bolometric luminosities relatively dominated by their X-ray emission.

2. Origin of the Hard X-ray Emission: Low Radiative Efficiency Accretion

We argue that the X-ray power-law emission is most likely to be due to accretion onto the central, supermassive black holes, via low-radiative efficiency accretion (Allen et al. 2000, Di Matteo et al. 2000).

The broadband spectral energy distributions for these galaxies, which accrete from their hot, gaseous halos at rates comparable to their Bondi rates, can be explained by low-radiative efficiency accretion flows in which a significant fraction of the mass, angular momentum, and energy are removed from the flows by winds. The observed suppression of the synchrotron components in the radio band (Di Matteo et al. 1999, excluding the case of M87) and the systematically hard X-ray spectra which are interpreted as thermal bremsstrahlung emission,

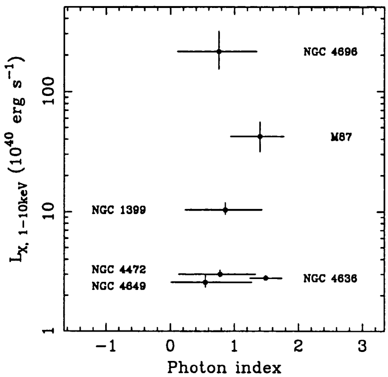

Figure 1. The intrinsic 1–10 keV luminosities of the detected power-law components as a function of the observed photon index, Γ. Error bars are 90% confidence limits.

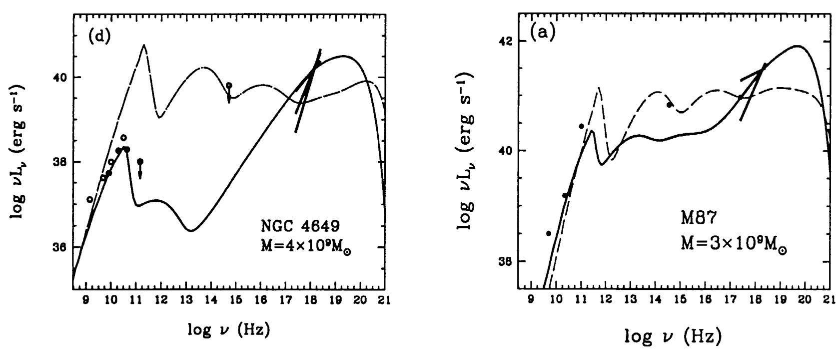

Figure 2. Spectral models calculated for ADAF with outflows and without outflows (dashed lines) are shown for two representative cases (for the other objects, see Di Matteo et al. 2000). The solid dots are the best constraints on the core emission. The thick, solid lines indicate the slopes and fluxes obtained from the ASCA analysis.

support the conjecture that significant mass outflow is a natural consequence of systems accreting at low-radiative efficiencies (Di Matteo et al. 2000).

References

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