X-RAY CONSTRAINTS ON ACCRETION AND STARBURST PROCESSES IN GALACTIC NUCLEI

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Abstract. Although the galaxies in our sample are heterogenous in their optical classifications (LLAGN: M51, NGC 3147, NGC 4258; LINER: NGC 3079, NGC 3310, NGC 3998, NGC 4579, NGC 4594; starburst: M82, NGC 253, NGC 3628, NGC 6946), they are fit well by a "canonical" spectrum with a hot, optically-thin thermal component with $T \sim 8 \times 10^6$ K and an absorbed ($N_H \sim 10^{22}$ cm^{-2}) power-law with an energy index $\alpha \sim 0.7 - 0.8$. Both the "soft" component, most likely due to SN or superwind-heated ISM, and the "hard" power-law, most likely due to a micro-AGN and/or blackhole candidates, appear to be common in low-activity galaxies. If the soft component is associated with a superwind outflow, than $\sim 10\%$ of the X-ray emission is due to "swept-up" ISM rather than superwind emission. The abundance of Fe relative to α-process elements tends to be sub-solar, possibly due to dust-depletion and/or type-II SN enrichment. The lack of short-term variability in the hard component suggests that if it is due to an AGN, then the mode of accretion is probably fundamentally different from "normal" Seyfert galaxies.

1. Overview of Results

The *ASCA* X-ray spectra of the galaxies in this sample were fit with a Raymond-Smith plasma model along with an absorbed power-law ($F_v = NE^{-\alpha}$) which provided the best overall fit to the data (see Ptak 1997, Ph.D. thesis for more details). Table 1 shows the statistically-weighted mean (μ) and variance (σ) for each fit parameter. Note that σ should be taken as

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the general spread of the fit values since the fit parameter distributions are not typically symmetric. Thermal fits to the hard component are also acceptable and resulted in a weighted mean temperature of 6×10^7 K. Soft X-ray line emission is most prominent in M51, M82, NGC 253 and NGC 4528, where variable abundance fits show that the relative Fe/α-process elemental abundance tends to be significantly sub-solar. Long-term X-ray variability (on time scales of months to years) is evident in several sources, while no significant short-term (time scales of less than one day) variability is detected. In several cases the X-ray morphology clearly differs in the 0.5-2.0 keV and 2.5-10.0 keV bandpasses which also implies that more than one emission component is present.

TABLE 1. Raymond-Smith + Power-law Fit Results

Parameter	μ	σ
N_H ($\times 10^{20}$ cm^{-2})	4.9	4.9
kT (keV)	0.70	0.10
A†	0.043	0.028
$N_{H,hard}$ ($\times 10^{22}$ cm^{-2})	1.2	1.4
α	0.71	0.41

$N_{H,hard}$ is the additional absorption column applied only to the power-law. † Abundance relative to solar.

2. Discussion

If the soft-component emitting gas is heated by a superwind, then a simple energetic argument suggests that the direct emission of supernovae (i.e., the ejecta that forms the superwind) contributes only $\sim$ 10% of the emission, suggesting that the majority of the X-ray flux is due to swept-up ISM that has been heated (see Ptak et al. 1997, AJ, 113, 1286). The radiative lifetime of the gas is on the order of 10^8 years and $\sim 10^4$ SN are required to provide the heating. The spectral form of the hard component is most consistent with AGN emission, while blackhole candidates may also be contributing (e.g., some of the point sources in NGC 253 are prominent above 2 keV). An AGN interpretation for the hard component is particularly attractive in LINERs (see Terashima et al., these proceedings). The lack of short-term variability implies an X-ray source extent $\gg R_{Schwarz} \sim 10^3 \frac{M}{10^6 M_\odot}$ lt–s, consistent with the interpretation that the accreting gas in these sources is optically-thin (i.e., lacking a geometrically-thin disk) as suggested by the advection-dominated accretion flow models.