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A multi-instrument comparison of the hot ISM in elliptical galaxies

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Abstract. Consistent metallicities are now obtained in X-ray bright galaxies, using the Chandra ACIS and XMM PN, MOS and RGS detectors. With two temperature models, the Fe metallicity of the gas is typically solar, similar to Mg, Si, and S, but the O abundance is about half solar. These values are in conflict with models, which predict a metallicity 3-5 times higher and a Fe to O ratio near unity. This suggests that a significant fraction of metals are not becoming mixed into the hot galactic atmosphere.

Keywords. X-rays: galaxies, galaxies: ISM

We appear to be reaching an observational consensus for the metallicity of the hot gas. The metals enter the hot gas through mass loss from AGB stars plus the metals from Type Ia supernovae, which should lead to a hot ambient medium with a metallicity of 3-5 times the solar value of Fe. Supernovae should heat the gas to temperatures above the velocity dispersion temperature, an observational feature that has been known for some time. However, measuring the metallicity has been problematic and has depended upon whether one adopts one or two temperature components for the hot plasma. We used four instruments to determine the temperature for the same X-ray bright galaxies: the Chandra ACIS-S; the XMM-Newton Epic (PN and MOS); and the XMM-Newton Reflection Grating Spectrometer (RGS).

As shown in Ji *et al.* (2009, *ApJ*, 696, 2252), there is good consistency in the fits for NGC 4649 from all instruments. The abundances for Mg, Si, S, and Fe are about the same, with a value near 1.4 times the solar value, using the metallicity calibration of Grevesse and Sauval (1998). The O and Ne values are about 0.7 solar, about half that of the heavier elements. There is a discrepancy between the Chandra ACIS-S and XMM-Newton values for O, with the Chandra abundance being lower. For nine bright galaxies, we fit two-temperature models and find that he median abundances, relative to solar are 0.86 (Fe), 0.79 (Si), 0.81 (Mg), and 0.44 (O). No galaxy has a metallicity exceeding about 1.5 solar in Fe. The 2:1 ratio of Fe to O, seen in all objects with good data, has been reported previously. This distribution of metal enrichment is consistent with 65-85% of the metal enrichment coming from Type Ia SNe.

The results are in conflict with basic expectations. The metallicity is low by at least a factor of three, and this problem worstens for the lower L_X galaxies. This conflict might be removed if somehow supernovae ejecta did not mix effectively. In this case, one would expect the abundance ratios to be like that of the stars, but the O/Fe and O/Mg ratios are half that of the stars. Furthermore, there is no correlation between the stellar Fe abundance and the hot gas Fe abundance, which would be expected if the hot gas metallicity were dominated by the AGB mass loss phase. Perhaps some of this can be resolved with models that restrict the mixing of metals, and there are some presentations at this meeting that address these issues.