A COMBINED XMM-NEWTON AND CHANDRA STUDY OF THE ULIRG MRK 273

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ABSTRACT

We present a compared analysis of a 23 ks XMM-*Newton* and a 47 ks *Chandra* observation of the Ultraluminous Infrared Galaxy Mrk 273. The hard X–ray spectrum can be modelled by a highly absorbed ($\sim 7 \times 10^{23}$ cm^{-2}) power law plus a Fe Kα emission line. The Fe line is broad ($\sigma = 260^{+370}_{-170}$ eV), suggesting possible superposition of a neutral line at 6.4 keV and a blend of ionized iron lines from Fe XXV and XXVI. The broad band spectrum requires three collisionally ionized plasma components, which may be associated with star–forming regions, having temperatures of about 0.3, 0.8 and 5 keV. The thermal emission at ~ 0.3 keV extends on ~ 45 kpc embracing the long tidal tail of the merger. Interestingly, thermal emission at ~ 0.7 keV seems to be ubiquitous in ULIRGs, probably associated with circumnuclear starburst. A high temperature ($kT > 5$ keV) thermal component is also detected in two other ULIRGs (namely NGC 6240 and Arp 220). The absorption corrected X–ray luminosity ($L_{2-10\,keV} \sim 7 \times 10^{42}$ erg s^{-1}) is $\sim 0.2\%$ of the far–IR luminosity, similar to typical values found in pure starbursts. The thermal contribution to the soft X–ray luminosity is approximately $0.2 - 0.7 \times 10^{42}$ erg s^{-1}, comparable to those found in NGC 6240 and other starburst dominated ULIRGs.

Key words: galaxies: individual: Mrk 273 - galaxies: individual: Mrk 273x - galaxies: Seyfert - X-rays: galaxies.

1. XMM-NEWTON

The XMM-*Newton* spectrum can be modelled by three collisionally ionized plasma components, a highly absorbed ($\sim 7 \times 10^{23}$ cm^{-2}) power law and a neutral Fe Kα line (Fig. 1). The highest spectral resolution and collecting area of XMM-*Newton* has allowed to resolve the iron line complex profile, which may originate by a superposition of two unresolved components: a neutral Fe Kα line at 6.4 keV, probably associated with a Compton–thick torus, and a blend of Fe XXV and XXVI lines at 6.7 and 6.97 keV respectively. The ionized iron lines can be, indeed, produced by an optically thin hot ($kT > 5$ keV) plasma, as observed at least in two other ULIRGs: namely NGC 6240 (Boller et al., 2003) and Arp 220 (Iwasawa et al., 2005). The best fit to the $0.3-10$ keV PN spectrum is obtained using three thermal plasma components with temperatures of $0.31^{+0.09}_{-0.07}$, 0.78 ± 0.08 and $5.4^{+2.6}_{-1.3}$ keV, a highly absorbed power law and a neutral Fe Kα line (Fig. 1). According to this model the emission below about 4 keV is of thermal origin.

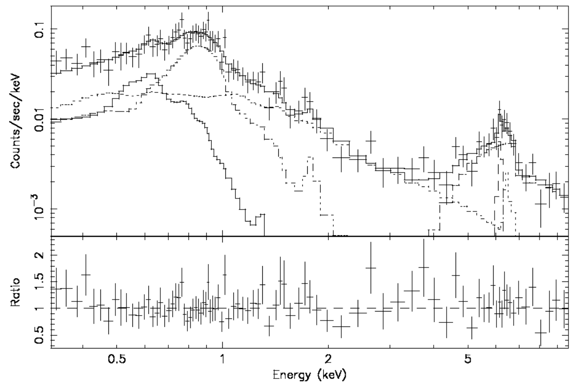

Figure 1. The EPIC–PN spectrum of Mrk 273 fitted with three different temperature thermal emission models, a highly absorbed power law and a neutral Fe Kα line. Each model component is displayed.

2. CHANDRA

From the *Chandra* image a soft, extended (~ 45 kpc) X–ray halo, surrounding the nucleus and embracing the long tidal tail of the merger, is clearly apparent (Fig. 2). The spectrum of the X–ray halo is that of a hot diffuse plasma with a temperature of 0.38 ± 0.04 keV (Fig. 3). While the spectrum of the nuclear region (Fig. 4) is best fitted by two thermal components, a highly absorbed power law and a neutral Fe Kα line. For Mrk 237 the unobscured X–ray luminosity is a more modest fraction of the bolometric luminosity than in typical AGNs, suggesting additional star formation, in agreement with the detection from mid–infrared spectroscopy of very powerful star formation in this source.

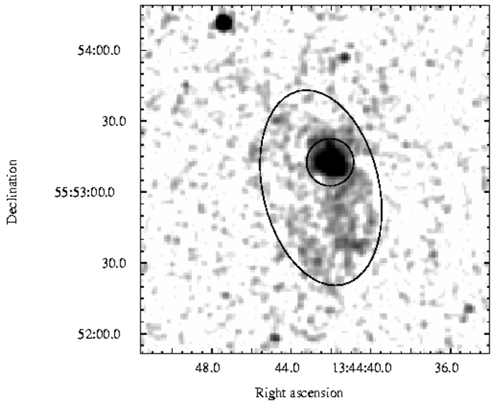

Figure 2. Adaptively smoothed $0.3-10$ *keV Chandra image of Mrk 273 with a smoothing scale of 2 pixels (*$\sim 1''$*). The circle has a radius of* $10''$ *and is centered at the peak of the hard X–ray emission. The ellipse has a size of* $42'' \times 25''$*.*

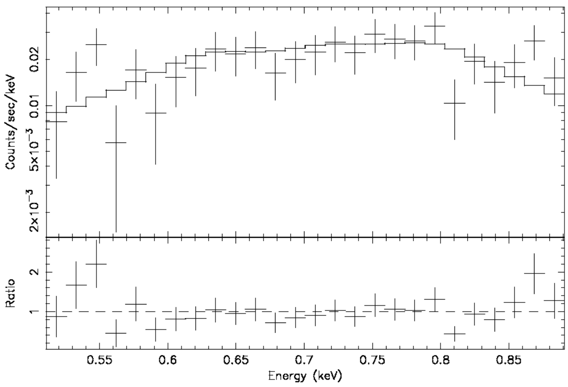

Figure 3. The $0.5-0.9$ *keV unbinned spectrum of the extended hot gas halo. A single APEC model with a temperature of* 0.38 ± 0.04 *keV provides a satisfactory fit.*

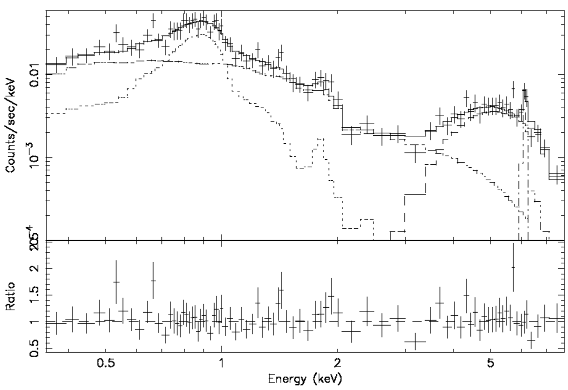

Figure 4. The $0.3-8$ *keV ACIS–S spectrum of the inner* $10''$ *region fitted with two thermal plasma components, a highly absorbed power law and a narrow Fe K*α *line at 6.4 keV.*

3. DISCUSSION AND CONCLUSIONS

The temperatures of the three plasma components found in Mrk 273 are remarkably similar to those observed in other ULIRGs (e.g. NGC 6240 and Arp 220) and in the local starburst galaxy NGC 253 (Pietsch et al., 2001). The thermal emission at ~ 0.3 keV, as clearly shown from the *Chandra* image, extends on a large scale (~ 45 kpc) and embraces the long tidal tail of the merger. Therefore, it must be associated with hot gas distributed in the halo. Interestingly, thermal emission at ~ 0.7 keV seems to be ubiquitous in the spectra of ULIRGs, probably being associated with a nuclear or circumnuclear starburst (Franceschini et al., 2003). The presence of a high temperature (> 5 keV) thermal component is less frequently observed, but not so unusual, being also detected in the XMM-*Newton* spectra of NGC 6240 (Boller et al., 2003) and Arp 220 (Iwasawa et al., 2005). The ratio of the $2-10$ keV unabsorbed X–ray luminosity of the highest temperature thermal component to the bolometric luminosity in Mrk 273 is $L_{2-10\,\mathrm{keV}}/L_{FIR} \simeq 7 \times 10^{-5}$ ($L_{FIR} = L(8-1000\,\mu\mathrm{m} \sim L_{bol})$, a factor of 20 smaller than in NGC 6240 and a factor of 5 larger than in Arp 220.

We analyzed the X–ray spectral properties of Mrk 273 combining the high throughput of XMM-*Newton* with the high spatial resolution of *Chandra*.

Chandra spatial resolution allowed to study separately the hot gas halo extended emission from the nuclear one. The spectral analysis of the two regions has revealed that the temperature of the extended hot gas halo is 0.38 ± 0.04 keV and in very good agreement with XMM-*Newton* results. From the XMM-*Newton* spectrum we found a broad Fe Kα emission line with a high statistical significance (>99% c.l.). We suggested the superposition of multiple unresolved iron line features: one from neutral iron at 6.4 keV ($EW \sim 170$ eV) and one from a blend of Fe XXV at 6.7 keV ($EW \sim 120$ eV) and Fe XXVI at 6.97 keV ($EW < 85$ eV). The emission below about 4 keV can be interpreted in terms of purely thermal emission, therefore involving the presence of a hot gas associated with regions of intense star formation.

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