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Supermodel analysis of the hard X-ray excess in the Coma cluster

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Abstract. The Supermodel provides an accurate description of the thermal contribution by the hot intracluster plasma which is crucial for the analysis of the hard excess. The Supermodel analysis of the *BeppoSAX*/PDS hard X-ray spectrum confirms the previous results of Fusco-Femiano *et al* (2004), namely an excess at the c.l. of $\sim 4.8\sigma$ and a non-thermal flux of $1.30 \pm 0.40 \times 10^{-11}$ erg cm^{-2} s^{-1} in the energy range 20-80 keV. Here we show a robust evidence of the compatibility between the *BeppoSAX* and *Suzaku* (Wik *et al* 2009) spectra that is a further confirmation of the presence of a nonthermal component in hard X-ray spectrum of the Coma cluster.

Key words. Galaxies: clusters: general — Galaxies: clusters: individual (Coma) — Intergalactic medium — Radiation mechanisms: non-thermal — X-rays: galaxies: clusters.

1. Introduction

The Supermodel (SM) describes the density and temperature profiles when we consider the entropy-modulated equilibrium of the intracluster plasma (ICP) within the potential wells provided by the dominant Dark Matter (Cavaliere, Lapi & Fusco-Femiano 2009). *BeppoSAX* detected the presence of non thermal (NT) radiation in excess of the thermal ICP emission in the Coma cluster (Fusco-Femiano *et al* 1999; 2004; thereafter FF04). This evidence has been claimed also by *RXTE* observations (Rephaeli, Gruber & Blanco 1999; Rephaeli & Gruber 2002) reporting NT fluxes in the 20-80 keV energy band in agreement with the *BeppoSAX* values.

Suzaku observations (Wik *et al* 2009, thereafter W09) constrain the thermal component by the hot ICP using a joint *XMM-Newton* & *Suzaku*/HXD-PIN analysis reporting an upper limit of $\sim 6 \times 10^{-12}$ erg cm^{-2} s^{-1} in the energy range 20-80 keV for the NT emission (photon index $\Gamma = 2$) with an average temperature of 8.45±0.06 keV. Also, they found an excess at c.l. above 4σ with a *XMM-Newton* best-fit value of 8.2 keV in the *Suzaku*/HXD-PIN FOV, in agreement with the results of FF04. With our SM analysis we will show that the marginal ev-

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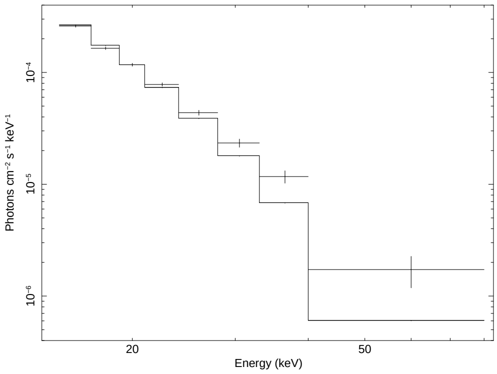

Fig. 1. The data represent the hard X-ray (HXR) spectrum of the Coma cluster observed by *BeppoSAX*/PDS (FF04). The continuous line is the SM thermal ICP emission.

idence of a NT component in the *Suzaku* observations is due to two combined causes: loss of NT flux for the smaller FOV of the HXD-PIN with respect to the *BeppoSAX*/PDS and *RXTE* FOVs, and higher average temperature derived by the joint analysis.

2. SM analysis of the hard excess

The ICP temperature and density profiles derived by the SM analysis of the Coma cluster (see Fusco-Femiano et al 2009) determine the cluster thermal emissivity in the energy range 15-80 keV. Fig. 1 compares the SM thermal spectrum with the PDS data (FF04). At $E \geq 20$ keV we obtain an excess at the c.l. of $\sim 4.8\sigma$ with a flux in the energy range 20-80 keV of $1.30 \pm 0.40 \times 10^{-11}$ erg cm^{-2} s^{-1} for an assumed photon index $\Gamma = 2$. The significance and the flux of the NT component are consistent with the previous analysis of FF04.

3. Discussion and conclusions

A relevant point emerges from the analysis of W09. They report that with a *XMM-Newton* average temperature of 8.2 keV, a nonthermal excess with c.l. greater than 4σ is present in the *Suzaku* data, without including systematic effects. This result implies that the HXD-PIN spectrum is consistent with the PDS spectrum of FF04 and therefore in disagreement with the PDS spectrum of Rossetti & Molendi (2004) that found a very marginal c.l. for the excess using the same temperature value and without including systematic effects.

We address the consistency of the *Suzaku* and *BeppoSAX* spectra with the following tests: *a)* we consider the smaller FOV of *Suzaku* HXD-PIN with respect to that of the PDS and temperature profile for an average T = 8.2 keV; in this case, we obtain a NT flux of $1.05 \pm 0.41 \times 10^{-11}$ erg cm^{-2} s^{-1} and a lower NT excess at the c.l. of $\sim 4\sigma$ in agreement with the W09 analysis. *b)* we use the *Suzaku* FOV and temperature profile that gives an average T of 8.45 keV. In this case, the NT flux is $8.7 \pm 4.2 \times 10^{-12}$ erg cm^{-2} s^{-1} due to the smaller HXD-PIN FOV and the higher average temperature. This flux value is consistent with the upper limit of 6×10^{-12} erg cm^{-2} s^{-1} reported by W09. Thus our SM analysis of the PDS spectrum reproduces the two results present in the W09 analysis: an excess at the c.l. of $\sim 4\sigma$ for T =8.2 keV, and the upper limit for the NT flux with T =8.45 keV. All this reinforces the consistency of the PDS and HXD-PIN spectra and therefore the presence of an hard tail in the Coma cluster spectrum. The PDS spectrum gives a hard excess with significance above 4σ *also* for an ICP average temperature of 8.45 keV thanks to its FOV, a factor ~ 4 greater than the HXD-PIN FOV.

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