Journal of The Korean Astronomical Society
37: 579 ∼ 581, 2004

DETECTION OF EMISSION FROM WARM-HOT GAS IN THE UNIVERSE WITH XMM?

Stuart Bowyer[1] and Alexey Vikhlinin[2]
[1]Space Sciences Laboratory, University of California, Berkeley, California, USA
[2]Harvard-Smithsonian Center for Astrophysics, Cambridge, Massachusetts, USA
E-mail: bowyer@ssl.berkeley.edu, alexey@head-cfa.harvard.edu

ABSTRACT

Recently, claims have been made of the detection of "warm-hot" gas in the intergalactic medium. Kaastra et al. (2003) claimed detection of $\sim 10^6$ K material in the Coma Cluster but studies by Arnaud et al. (2001), and our analysis of the Chandra observations of Coma (Vikhlinin et al. 2001), find no evidence for a 10^6 K gas in the cluster. Finoguenov et al. (2003) claimed the detection of 3×10^6 gas slightly off-center from the Coma Cluster. However, our analysis of ROSAT data from this region shows no excess in this region. We propose an alternative explanation which resolves all these conflicting reports. A number of studies (e.g. Robertson et al., 2001) have shown that the local interstellar medium undergoes charge exchange with the solar wind. The resulting recombination spectrum shows lines of O VII and O VIII (Wargelin et al. 2004). Robertson & Cravens (2003) have shown that as much as 25% of the Galactic polar flux is heliospheric recombination radiation and that this component is highly variable. Sporadic heliospheric emission could account for all the claims of detections of "warm-hot" gas and explain the conflicts cited above.

Key words : the intergalactic medium – X-ray

I. INTRODUCTION

Virtually all models of the evolution of intergalactic material from the era of re-ionization predict material at 10^4 K, warm gas at $\sim 10^5$ K, warm-hot gas at $\sim 10^6$ K, and hot gas in clusters of galaxies. The best models, as reported at this conference, show fascinating detail at the interfaces between these components. The theoretical models appear to be firmly based.

But what is the observational situation regarding these components? There is strong evidence for the presence of 10^4 K material. Hot gas in clusters of galaxies is a major component of the Universe and has been studied for almost thirty years. However, there is little observational evidence for the warm and warm-hot components of the IGM.

II. OBSERVATIONS WITH XMM

Kaastra et al. (2003) claimed detection of $\sim 10^6$ K material in the core of the Coma Cluster using XMM data. However, previous studies of the core of the Coma Cluster by Arnaud et al. (2001) using XMM data found no evidence for 10^6 K gas in the cluster. Our analysis of *Chandra* observations of Coma (Vikhlinin et al. 2001) also found no evidence for a 10^6 K gas in the cluster. We emphasize that the revised calibration of the *Chandra* instrument subsequent to our initial analysis did not change these negative findings.

Finoguenov et al. (2003) found 3×10^6 K gas slightly off-center from the Coma Cluster with XMM. This emission was present in several individual locations, but was most prominent in a field dubbed "Coma-11". Finoguenov et al. (2003) claimed to show this emission was from a filament fortuitously aligned in the line of sight direction to the Coma Cluster. In the analysis of Finoguenov et al. a decomposition of the observed XMM flux was carried out into a background, hard emission from the hot ICM, and soft emission from a 1-degree scale filament around Coma. The consequence of the proposed decomposition is that the cluster plus filament flux is at least a factor of 3 higher than the constant background in all ROSAT energy bands.

We performed a spatial analysis of the ROSAT All-Sky Survey data for the Coma-11 XMM field. We took Finoguenov et al.'s model and made predictions for the ratio of the background and the cluster plus soft components in the ROSAT bands. The flux in the soft ROSAT bands is only a factor of 1.4-1.8 above the background measured from ROSAT data at 4 degrees from the cluster. This is completely consistent with the expected emission from the hot ICM in the cluster with no evidence of a warm-hot component.

The contradictory results obtained from the ROSAT and XMM observations are quite puzzling. However, a new source of "10^6 K" radiation has been recently identified. A number of studies (e.g. Robertson et al. 2001 and references therein) have shown that the local interstellar medium undergoes charge exchange with the solar wind that results in highly ionized material. This material de-excites producing X-ray emission whose spectrum looks similar to that of thermally ion-

Proceedings of The 3rd Korean Astrophysics Workshop on
Cosmic Rays and Magnetic Fields in Large Scale Structure

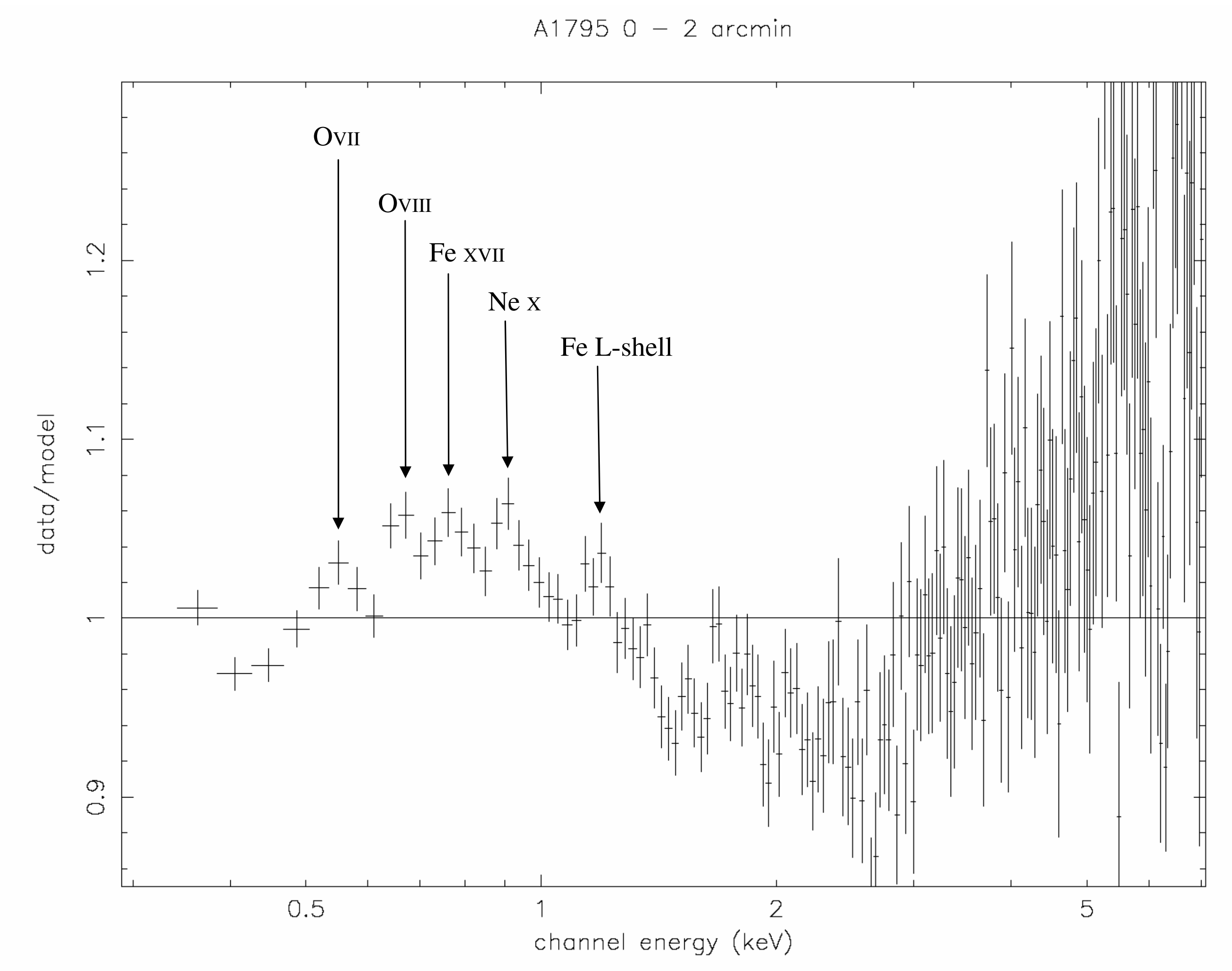

Fig. 1.— The spectrum of the cluster of galaxies A1795 taken with the XMM satellite.

ized plasma at 10^6 K. This spectrum shows lines of O VII and O VIII (Wargelin et al. 2004). Robertson & Cravens (2003) has shown that as much as 25% of the Galactic polar flux is heliospheric recombination radiation and that this component is highly variable.

In Fig. 1 we show a spectrum taken with the XMM satellite of the cluster of galaxies A1795 taken from Nevalainen et al. (2003).The higher energy portion of this spectrum is well characterized by a cluster thermal gas. The low energy portion of this spectrum is what one would expect from de-excitation of the local ISM after charge exchange with the solar wind.

The results of Finoguenov et al. (2003) for the Coma Cluster can readily be explained if the majority of the separate XMM images of the cluster had only emission from the thermal cluster gas, while the areas exhibiting an excess emission (and in particular the Coma 11 field) had an admixture of heliospheric emission. The observational scenario for this situation is depicted schematically in Fig. 2.

III. CONCLUSIONS

The claim by Kaastra et al. (2003) for the detection of a warm-hot component of the IGM in the Coma Cluster is contradicted by two other studies of the cluster and is certainly spurious. The XMM data taken at the outer edge of the Coma Cluster and claimed by Finoguenov et al. (2003) to be emission from a filament fortuitously aligned in the direction of the cluster, is in conflict with ROSAT data taken of this region. The XMM data in this direction is most likely a mixture of Solar heliospheric emission and emission from the well studied hot cluster gas.

We conclude that while XMM has the potential to find warm and warm-hot gas, these components have not yet been detected.

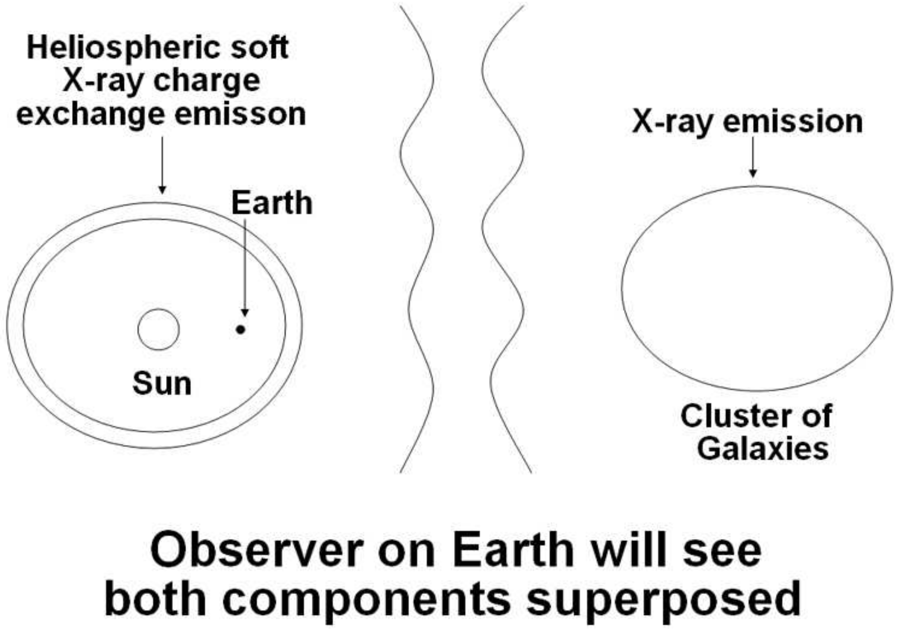

Fig. 2.— A cartoon representation of the emission that would be observed in the direction of a cluster of galaxies in the case of enhanced Solar heliospheric emission.

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