Coronal lines in bright X-ray sources in globular clusters: a challenge for XMM

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ABSTRACT

A BeppoSAX observation of the burster source X1820-303 in the globular cluster NGC 6624 have unveiled possible coronal emission lines. The feasibility of a study of such lines with the RGS on board XMM is discussed in this paper.

1. Introduction

A program to observe a sizeable sample of X-ray luminous sources in globular clusters with the Italian-Dutch observatory BeppoSAX (Boella et al. 1997a) is ongoing. Preliminary results of this program are in Guainazzi et al. 1998 and Guainazzi 1998. The spectra of all the observed sources are adequately described by a rather absorbed ($N_H \simeq 3$–7×10^{21} cm^{-2}) Comptonized spectra plus a thermal component. In the brightest source of the sample (X1820-303 in NGC 6624) a set of four emission lines are required by the fit at high statistical level. Their Equivalent Widths (EW) are in the range 8 to 26 eV, which is below the detection limit in the fainter sources. Their energies (E), EW and likely identification are listed in Table 1 below. However, the low statistics

Table 1: Coronal lines in X1820-303

E (keV)	EW (eV)	Id
$2.1\pm^{0.3}_{0.2}$	$8\pm^{5}_{6}$	Si XIV
$2.50\pm^{0.12}_{0.07}$	$26\pm^{7}_{14}$	S XV–XVI
$2.96\pm^{0.06}_{0.07}$	21 ± 6	Ar < XVII
$7.1\pm^{0.2}_{0.3}$	15 ± 11	Fe XXVI

and the moderate energy resolution available in the BeppoSAX imaging instruments ($\simeq 8\%$ FWHM at 6 keV, degrading blue-ward approximately as $E^{-1/2}$; Parmar et al. 1997; Boella et al. 1997b), does not allow the line profiles to be clearly measured. The residuals against the best-fit continuum are shown in Fig. 1. The broad "hump" between 2 and 3 keV *cannot* be modeled with any continuum component. Nonetheless, the weakness of the lines strongly hampers any attempt to derive physically self-consistent interpretations of the mechanisms which may produce them.

Emission lines from ionized species of intermediate elements and from L-shells of iron have been detected in several ASCA observations of Low Mass X-Ray Binaries. Generally the observed

lines can be well understood in terms of collisional plasma models (Angelini et al. 1995; Vrtliek et al. 1991; Angelini et al. 1998). However, the line-rich spectrum of CygX-3 has shown for the first time evidence for a radiative recombination continuum (Liedahl & Paerels 1996). If the lines originate from an Accretion Disk Corona (ADC), two main mechanisms may compete in creating the bulk of the line emission in the soft X-rays: radiative recombination and photoexcitation of bound-bound transitions. The brightest lines are expected from He-like states of N, O, Ne, Mg, Si, and S and from the L-shell iron complex in the range 0.73–1.18 keV. The emissivity of resonant excitation is expected to be $\gtrsim 5$ than of recombination in typical ADC conditions (Bautista et al. 1997). However, the resonant scattering lines become optically thick at hydrogen column densities of $\simeq 10^{18}$–10^{19} cm^{-2} (Krolik & Kriss 1995), whereas 10^{22} cm^{-2} is needed to make the photoionization continuum optically thick (cf. Netzer 1996). There is therefore enough room in the parameter space to allow both mechanisms to play a role in different sources. Moreover, scattering resonant lines cannot be observed in a totally spherically symmetric system, because as many photons are absorbed than re-emitted in every direction in this case. In order for the lines to appear, the exciting continuum must be, partly or totally, absorbed or blocked along the line of sight. Interestingly enough, this could be exactly the physical scenario in X1724-308 (in Terzan 2; Guainazzi et al. 1998)

We have tried to explore the power of the forthcoming XMM payload in performing soft X-ray spectroscopy on bright X-ray globular cluster sources, using the last July 1997 matrices. The best-fit models as seen by Beppo-SAX has been used as a "seed" for the simulations. X1820-086 has a 2–10 keV flux of about 160 mCrab and is therefore likely to be affected by pile-up in the EPIC/PN. For this source we performed therefore simulations of the expected 0-th order RGS spectrum, which is unfortunately limited in energy to 2.5 keV. The profile of the SiXIV line is clearly detected (see Fig. 2)

For other fainter sources, we have created "hybrid" models, by adding a set of lines as seen in X1820-086 (*i.e.*: with the same E and EW), and simulated the expected spectra in the EPIC/PN camera. Such simulations are admittedly only illustrative of the possible true physical scenario. The results for X1850-806 (in NGC 6712, 4 mCrab) are shown in Fig. 3 and 4. 10 and 25 ks of net exposure times have been assumed, respectively. In both cases, the lines are clearly detected against the best-fit continuum. Iron L-complex lines are also likely to be detected, notwithstanding the sharp low-energy absorption cut-off. Oxygen lines are instead likely to be too absorbed to be detectable.

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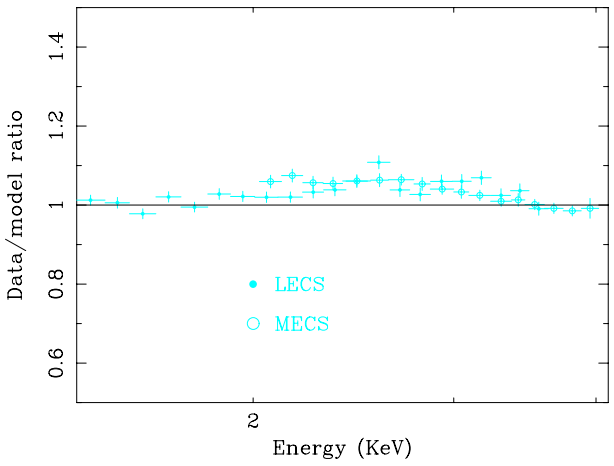

Fig. 1.— Spectral residuals against the best-fit continuum in the BeppoSAX observation of X1820-086

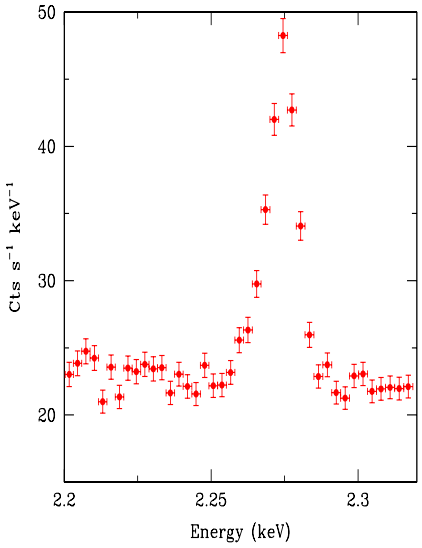

Fig. 2.— Profile of the SiXIV line in the RGS simulated spectrum of X1820-086 (in NGC 6624)

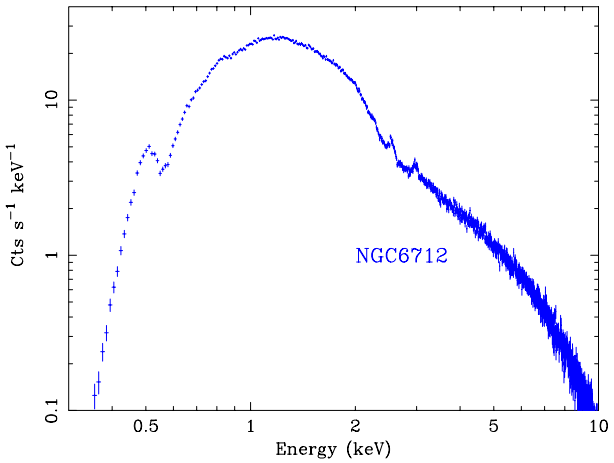

Fig. 3.— Simulated PN/EPIC "hybrid" spectrum of X1850-806 (in NGC 6712; details in text)

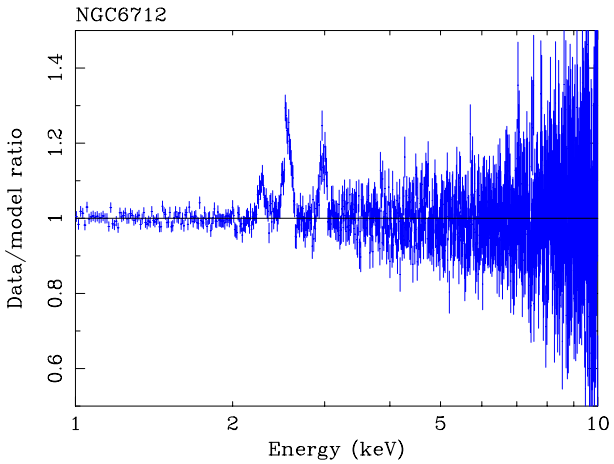

Fig. 4.— Residuals against the best-fit simulated continuum for X1850-806

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