Relativistically smeared iron lines in the spectra of bright NS LMXB

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Abstract. We present preliminary results of a study on three bright accreting low-mass X-ray binaries hosting a neutron star, based on XMM-Newton observations. These sources (GX 340+0, GX 349+2 and SAX J1808.4-3658) show a broad Fe Kα iron line in their spectra. This feature can be well described by relativistic line profile in each case; the good spectral resolution of the EPIC/PN and the high statistics spectra allow to put very good constraints on the disk geometry and ionization stage of the reflecting matter.

Keywords: accretion disks – stars: individual: GX 340+0, GX 349+2, SAX J1808.4-3658 — stars: neutron stars — X-ray: stars — X-ray: spectrum — X-ray: general
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INTRODUCTION

Broad asymmetric lines (FWHM up to 1 keV) at energies in the 6.4-6.97 keV range are often observed in the spectra of LMXBs, hosting a neutron star or a black hole. These lines are identified with radiative transitions of iron ions at different ionization states. To explain the large width of these lines it has been proposed that they originate from emission reprocessed by the accretion disk surface illuminated by the primary Comptonized spectrum. In this model, the combination of Doppler effects from the high orbital velocities and Special and General relativistic effects arising from the strong gravity in the neighborhood of the compact object smears and shifts the reflected features, so that the line will have a characteristically broad and asymmetric profile whose detailed shape depends on the inclination angle and on how deep the accretion disk extends into the compact object potential well. Evidence for such an origin has been accumulated during the years for AGNs [1], and only very recently for galactic black holes [2] and accreting NS of the atoll class [3, 4]. Thanks to the large effective area and its good spectral resolution, the EPIC/PN instrument on board XMM-Newton offers the oppurtunity to investigate and firmly constrain the spectral shape of the iron fluorescence lines in the spectra of bright accreting NS LMXB. Here we show results of three recent XMM observations of two bright Z-sources (GX 340+0 and GX 349+2) and of the accreting ms X-ray pulsar SAX J1808.4-3658 during its last outburst.

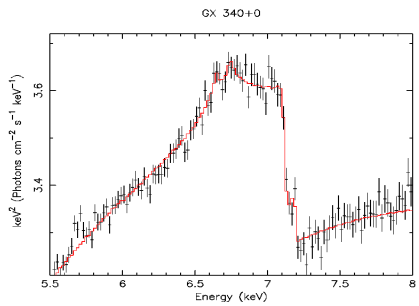

FIGURE 1. Plot of the unfolded spectrum, with the best-fitting model superimposed, in $E^2 f(E)$ representation for the GX 340+0 dataset.

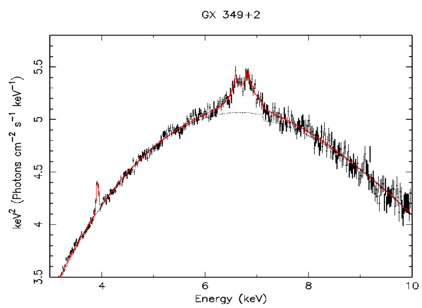

FIGURE 2. Plot of the unfolded spectrum, with the best-fitting model superimposed, in $E^2 f(E)$ representation for the GX 349+2 dataset.

DATA ANALYSIS AND RESULTS

GX340+0 and GX349+2 are two bright LMXBs, belonging to the class of the Z-sources. GX 340+0 was observed by XMM-Newton in September 2007. During the observation the source resided on its Horizontal Branch and displayed a 40% flux variability. In the spectrum we could identify a strong emission line, whose shape did not appreciatly changed, despite the change in source luminosity. The line is broad (sigma 0.25 keV),

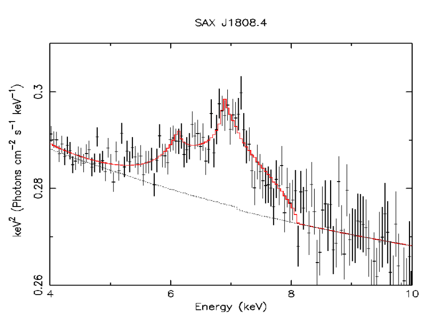

FIGURE 3. Plot of the unfolded spectrum, with the best-fitting model superimposed, in $E^2 f(E)$ representation for the SAX J1808.4 dataset.

and can be associated to highly ionized iron transition (Fe XXV). Using a relativistic line profile (diskline, [5]) we derived that the reflecting accretion disk extends down to 13±3 gravitational radii (R_g), the inclination of the disk is 34.6±1.3° and the emissivity profile of irradiating flux has a power law dependence, with index -2.50±0.01.

GX 349+2 was observed in 2008 March 28. The source shows a continuum emission that can be well fitted by a single optically thick Comptonized component. A strong emission line, is present in the Fe Kα region. The profile is rather symmetric and can be equally well fitted by a broad Gaussian profile (sigma 0.26 keV) or a relativistic profile (diskline). In this case, the best-fitting parameters are: a line energy at 6.76±0.02 keV, a inner disk radius < 25 Rg, outer disk radius > 1500 Rg, inclination angle 41° ±3° and emissivity power law index of -2.2±0.2.

The accreting ms X-ray pulsar SAX J1808.4-3658 was found in outburst on 2008 September 21 by RXTE. XMM-Newton observed it the 1st October for 63 ks. The continuum spectrum can be well decomposed into the sum of three components, which we interpret as thermal disk emission, thermalized emission from the magnetic caps and a Comptonized emission from an optically thin corona. Superimposed to this continuum a broad iron line was easily detected. The line, at energies 6.44±0.08 keV, indicates that the reflecting disk is weakly photo-ionized, the inner disk radius is < 12 Rg, the outer disk radius 200 R_g, the inclination $> 58°$ and the emissivity index -2.2±0.3. The line has a large equivalent width (120 eV).

CONCLUSIONS

We have shown preliminary results of the spectral study of 3 bright accreting NS LMXB. Broad and strong emission lines in the iron region can be used to determine the geometry and the physical conditions of the reflecting plasma. The future launch of the Simbol-X satellite will allow to further extend these studies covering in a self-consistent way the broadband continuum of these sources and to detect other reflection signatures above 10 keV.

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