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Discovery of absorption lines in Low Mass X–ray Binaries: MXB 1659–298 and GX 13+1

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Abstract. We present the results of *XMM-Newton* observations of two Low Mass X–ray Binaries where we found X–ray lines in absorption: the dipping, eclipsing source MXB 1659-298, and the bright LMXRB GX 13+1. The narrow absorption features are consistent with being due to resonant scattering of the Kα and Kβ lines of He- and H-like iron (Fe xxv and Fe xxvi), H-like calcium (Ca xx) Kα, Ne x and O viii.

Key words. LMXRB – GX 13+1 - MXB 1659–298

1. Introduction

High resolutions instruments on-board XMM-Newton and *Chandra* are revealing that absorption lines are common features among X–ray Binaries, and they are a useful probe of the nature of the circumsource matter.

Recently, we discovered narrow absorption lines from highly ionized elements in two Low Mass X–ray Binaries (LMXRB) with *XMM-Newton*.

MXB 1659-298 is a transient, bursting, dipping and eclipsing (orbital period of 7.11 hr) X-ray source. The results reported here are based on a pointed observation performed in February 2001, during the last outburst.

GX 13+1 is a persistent and bursting LMXRB for which an orbital period has not been found yet, although a modulation with a periodicity of about 25 days has been observed. ASCA observations of this source revealed the presence of an iron line in absorption (Ueda et al. 1998). GX 13+1 was observed with *XMM-Newton* several times during the Performance Verification phase both on- and off-axis. Here we focus on the results of three on-axis observations performed in 2000 March and April.

2. MXB 1659–298

The EPIC 0.5–10 keV lightcurve from this source displays all kind of variabilities: a type-I X–ray burst, severe dipping activity around orbital phase 0.8, X–ray eclipses. The X–ray emission out of the burst, out of eclipses, out of dipping activity is the so-called "persistent" emission.

The analysis of the spectrum during the persistent emission revealed structured and narrow residuals in the energy range typical of iron lines (6-7 keV). The best fit for the continuum was a blackbody, with temperature $kT_{\rm bb} = 1.30^{+0.01}_{-0.06}$ keV, and a radius, $R_{\rm bb}$, of

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$4.8^{+0.07}_{-0.03}$ km, plus a power-law (photon index of 1.90 ± 0.02) with a cutoff at around 15^{+29}_{-4} keV. In order to get a reasonable fit to the data other 3 discrete components are needed: an emission line at 6.5 keV and two Gaussian lines in absorption, at 6.64 ± 0.02 (equivalent width, EW, of -33^{+9}_{-20}) and at $6.90^{+0.02}_{-0.01}$ keV (EW=-42^{+8}_{-13}).

These lines are likely due to the absorption from highly ionized iron (Fe xxv and Fe xxvi).

The RGS persistent spectra (energy range 0.3-2.3 keV) revealed the presence of other four features in absorption: O viii 1s-2p line at $18.95^{+0.02}_{-0.01}$Å, O viii 1s-3p at $16.00^{+0.02}_{-0.01}$Å, O viii 1s-4p at 15.21 ± 0.01Å and Ne x 1s-2p at $12.15^{+0.02}_{-0.01}$Å.

The line widths are unresolved in the RGS and translate to velocities <600 km s^{-1} for O viii 1s-2p and <2300 km s^{-1} for the Fe xxvi Kα line observed in the EPIC spectrum (Sidoli et al. 2001).

3. GX 13+1

The EPIC spectra from this source revealed two strong absorption features at around 6.7 and 7.0 keV.These features are consistent with being due to resonant K shell absorption from highly ionized iron Fe xxv and Fe xxvi, respectively. In addition to the Fe xxvi (with EW=20 eV) and Fe xxv (with EW=50 eV) Kα absorption features, additional narrow absorption features can be identified, and are consistent with being due to Ca xx (at 4.1 keV, with EW$\sim$7 eV) and to Fe xxv (with EW=30 eV) and Fe xxvi Kβ (with EW=40 eV). Moreover, a deep edge at 8.83 keV is clearly required (produced by Fe xxv), together with an edge at 9.28 keV (due to Fe xxvi).

The line centroids of the Fe xxv and Fe xxvi Kα lines do not show evidence for any velocity shifts, except in one EPIC observation where blue-shifts of -2700 ± 2200 km s^{-1} (Fe xxv Kα) and -3900 ± 1700 km s^{-1} (Fe xxvi Kα) are measured.In this same observation, a blue-shift in the Ca xx feature of -5100 ± 2200 km s^{-1} is also detected (Sidoli et al. 2002).

4. Conclusions

Our discovery of absorption lines during persistent emission (in MXB 1659–298) revealed the existence of ionized absorbing plasma all around the central source, not related with the absorbing matter causing the dipping activity. This suggest a flattened geometry all around the source, above the accretion disk.

The orbital period of the source GX 13+1 is unknown, so we cannot estimate a geometry and size for the absorbing plasma around the central X–ray source. On the other hand, the fact that the EWs of the iron lines in absorption, are consistent with what found by Ueda et al. (2001) with ASCA few years before, suggests a stable geometry of the absorbing plasma around the source.

References

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