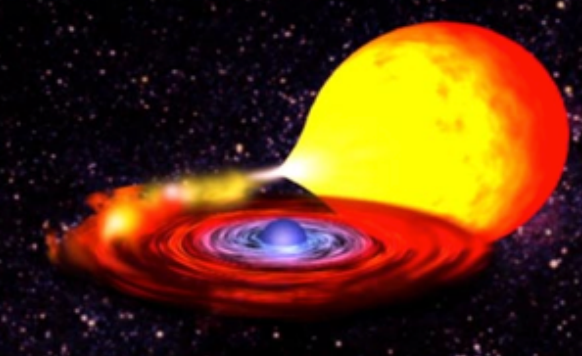
Spectral analysis of MXB 1728-34 with XMM-Newton



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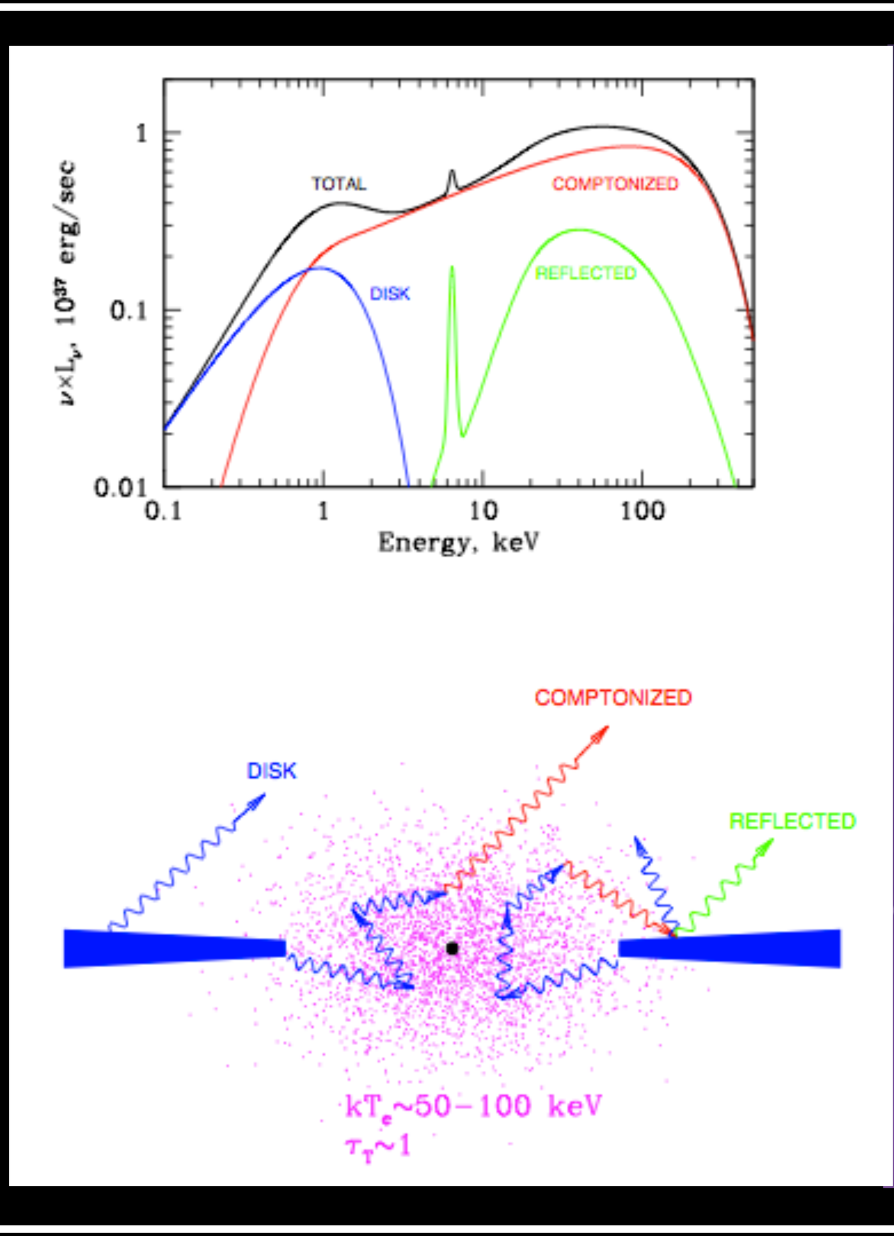
We have analysed an XMM-Newton observation of the Low Mass X-ray Binary and atoll source MXB 1728−34 on 2002 October 3rd. The source was in a low luminosity state during the XMM-Newton observation, corresponding to a bolometric X-ray luminosity of 5 x 10e36 ergs/s for a distance of 5.1 kpc. The 1−11 keV X-ray spectrum of the source, obtained combining data from all the five instruments on-board XMM-Newton is well fitted by a Comptonized continuum. Evident residuals are present at 6−8 keV which are ascribed to the presence of a broad iron emission line. This feature can be equally well fitted by a broad Gaussian, by a relativistically smeared line or by a self-consistent, relativistically smeared, reflection model. In the hypothesis that the iron line is produced by reflection from the inner accretion disk, we can infer important information on the physical parameters of the system, such as the inner disk radius, Rin ~ 18 Rg, and the inclination of the system with respect to the line of sight, 44° < i < 60°.

The iron line as a reflection component



The broad iron line in the energy range 6.4−7 keV has been detected in many X-ray systems such as AGN and X-ray binary systems containing either a black hole or a neutron star. **It could be produced from irradiation by hard X-rays of cold matter in the accretion disk.** When a hard X-ray photon hits the accretion disk, it is subject to different interactions such as Compton scattering, photoelectric absorption. The fluorescent iron line is produced to re-adjust the iron atom or ion after one of the two K-shell electrons is ejected following photoelectric absorption of an X-ray photon.

Fig. 1. Top panel: The three main components of the X-ray emission from an accreting black hole (top) and a plausible geometry of the accretion flow in the hard spectral state (bottom). *(Marat Gilfanov,2009, arXiv:0909.2567)*

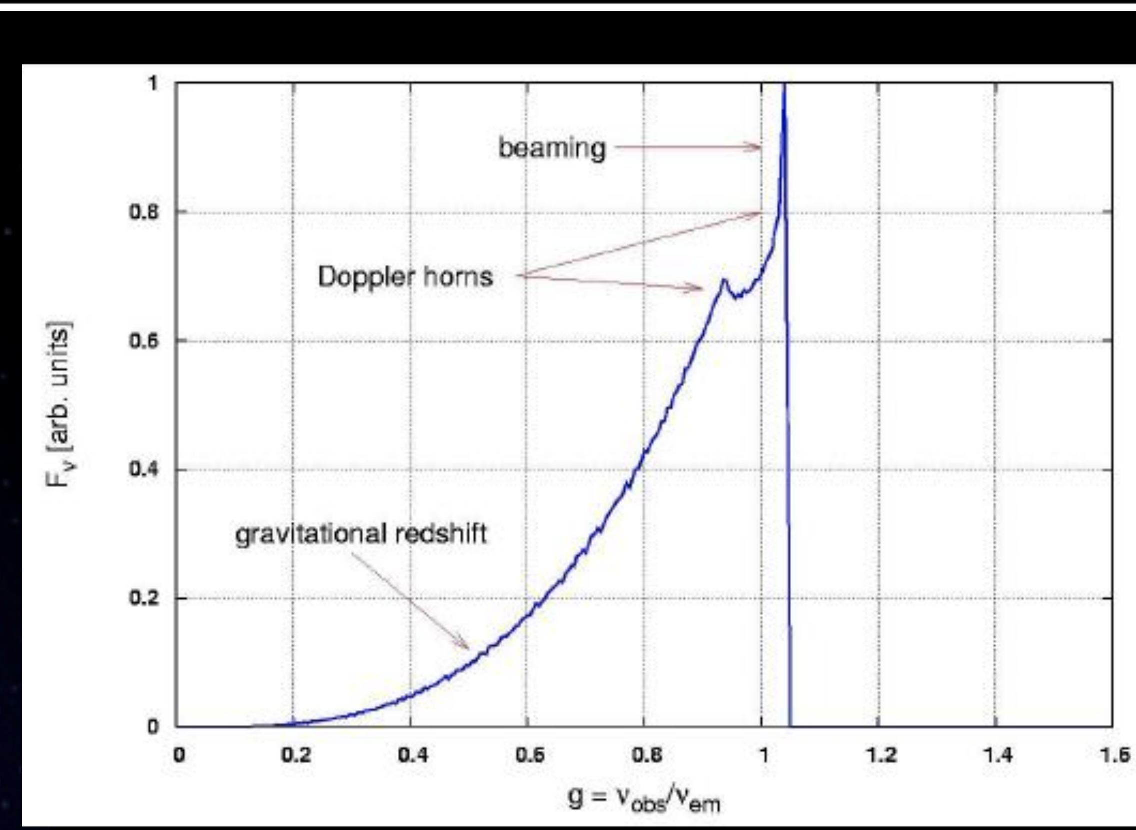


Fig. 2. The line profile results from the superposition of different effects: **Doppler shifts** (double-horns due to the approaching matter, blueshift, and receeding matter, redshift, respectively), **relativistic beaming** enhancing the blue peak, and **gravitational redshift** because of the strong gravitational field close to the compact object. *(Mueller, 2007, Proceedings of Science)*

The continuum

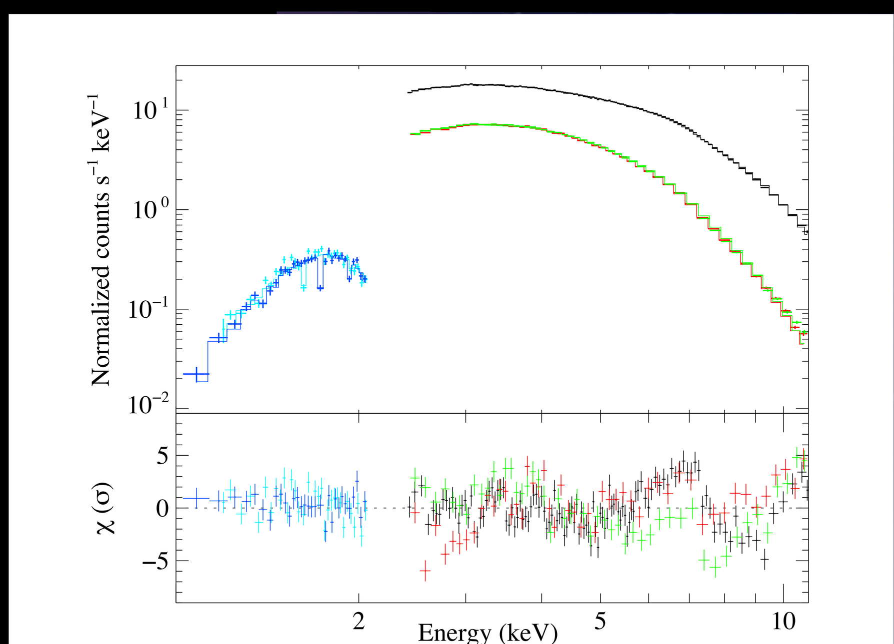


Fig. 3. Top panel: EPIC-pn (black), MOS1 (red), MOS2 (green), RGS1 (cyan), RGS2 (blue) data points of MXB 1728−34 in the range 1−11 keV. **Bottom panel:** Residuals (Data −Model) in units of sigmas for the continuum reported in Table 1.

Parameter	Value
N_H ($\times 10^{22} cm^{-2}$)	2.4 ± 0.1
kT_{seed} (keV)	0.59 ± 0.02
kT_e (keV)	2.74 ± 0.04
τ	16.5 ± 0.2
Norm	9.54 ± 0.02
Flux 2.0−10.0 keV (pn)	8.06
Flux 2.0−10.0 keV (MOS)	8.17 (MOS1) - 8.07 (MOS2)
Flux 1.0−2.0 keV (RGS)	0.186 (RGS1) - 0.185 (RGS2)
Total χ^2 (d.o.f.)	1732 (903)

Table 1. Best fitting parameters of the **continuum emission**. The model used is **const*phabs*compTT**. The aborbed flux is in units of 10e-10 erg cm-2 s-1.

Different models to fit the residuals

1. Gaussian line
E = 6.57 ± 0.05 keV
σ = 0.6 keV (frozen)
χ^2/dof = 1489/901

2. Diskline profile
E = 6.45 ± 0.06 keV
Betor = -2.8 ± 0.1
i = 60° (frozen)
Rin = 18 +3 −6 Rg
χ^2/dof = 1463/899

3. Relativistic line
E = 6.43 ± 0.07 keV
Index = 2.8 ± 0.1
i = 60° (frozen)
Rin = 19 +3 −4 Rg
χ^2/dof = 1464/899

4. Two absoption edges
E_1 = 7.5 keV
τ = 0.06 ± 0.01
E_2 = 8.5 keV
τ = 0.06 ± 0.01
χ^2/dof = 1519/899

5. Self reflection model
Betor = -2.7 (frozen)
Rin = 20 +29 −6 Rg
i > 44°
ξ = 660 (frozen)
χ^2/dof = 1463/900

Results

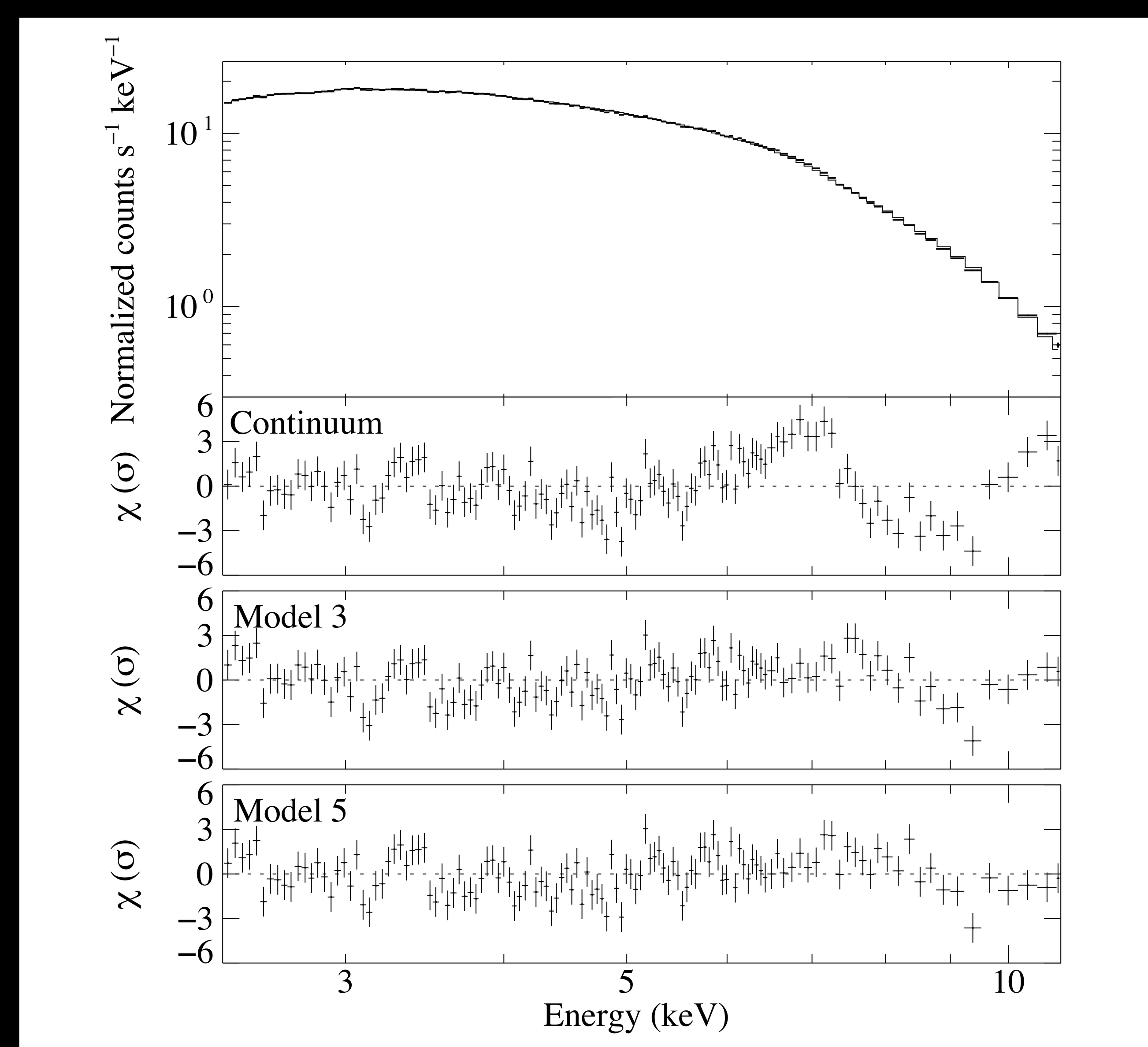


Fig. 4. Top panel: EPIC-pn data points of MXB 1728-34 in the range 2.4−11 keV. **Bottom panels:** Comparison of the residuals (Data−Model) in units of sigmas for the continuum, for Model 3 including a relativistic line (relline), and for Model 5 using a relativistic reflection component (reflion).

1. Gaussian line: Improvement of the fit with respect to the best fit continuum ($\Delta\chi^2$ = 243 for the addition of 2 parameters).
2. Diskline profile: The profile appears broad and possibly asymmetric. We ascribe this shape to Doppler and relativistic effects in the inner part of the accretion disk, which is coherent with a disk-reflection scenario.
3. Relativistic line: The results are perfectly consistent with the diskline model.
4. Two absorption edges: Comparison with the results obtained by D'Ai et al (2006). The fit is not as good as with the previous models. We favor in the interpretation of the iron feature as a broad emission line.
5. Self reflection model: Relativistic distorsions are required to take into account the broad line ($\Delta\chi^2$ = 89 for the addition of 2 parameters).

The line profile can be equally well fitted using a relativistic line or a self-consistent reflection model. The inclination angle of the system with respect to the line of sight is found to be > 44°, which is in agreement with the fact that this source does not show any dips in its lightcurve (which implies i < 60°). The inner radius of the accretion disk is estimated at 25–100 km from the neutron star center. That means that the disk would be truncated quite far from the neutron star surface. Usually a soft blackbody is required to fit the broad band X-ray spectra of LMXBs, interpreted as emitted by the accretion disk. This component is not significantly detected in the XMM-Newton spectrum. This is in agreement with a disk truncated relatively far from the neutron star.