PROCEEDINGS OF SCIENCE

X-ray spectra of SS 433: evidences of the supercritical accretion disc funnel?

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We have analyzed XMM-Newton spectra of SS 433. We use a model of the cooling X-ray jets which satisfies the observed jet line fluxes. We find an additional component in the spectrum of SS 433, the most probably a reflected radiation. The intrinsic radiation may come from the deep inner regions of the supercritical accretion disc funnel to be reflected in outer funnel walls ($r \approx 10^{11}$ cm). We estimate the spectrum of the intrinsic component and its X-ray luminosity, which exposes the reflecting observing gas, $L_x \geq 10^{38}$ erg/s.

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Introduction

We have studied X-ray spectra of SS 433 taken with the XMM-Newton in precessional phase of the most open accretion disc $\Psi = 0$ and in nearby phase $\Psi = 0.8$. The X-ray radiation of SS 433 is commonly considered as a radiation of the cooling jets (Brinkmann et al., 2006). We have developed such a cooling jet model with taking into account a free-free radiation, based on optically thin hot plasma model APEC (Smith et al., 2001ab; Smith, Brickhouse, 2000). We adopted the main jet parameters: the kinetic luminosity $L_k = 10^{39}$ erg/s and the total opening angle $\theta = 1.5^{\circ}$ as known from optical and X-ray observations (Fabrika, 2004). We use the multi-temperature jet model and the iron-line diagnostics method (Kotani, 1996) to determine the radius and temperature of the observed jet base. The model of the cooling X-ray jets satisfies well the observed jet moving line fluxes. Fig. 1 shows that there has to be an additional source of X-ray emission in SS 433 besides the jet radiation.

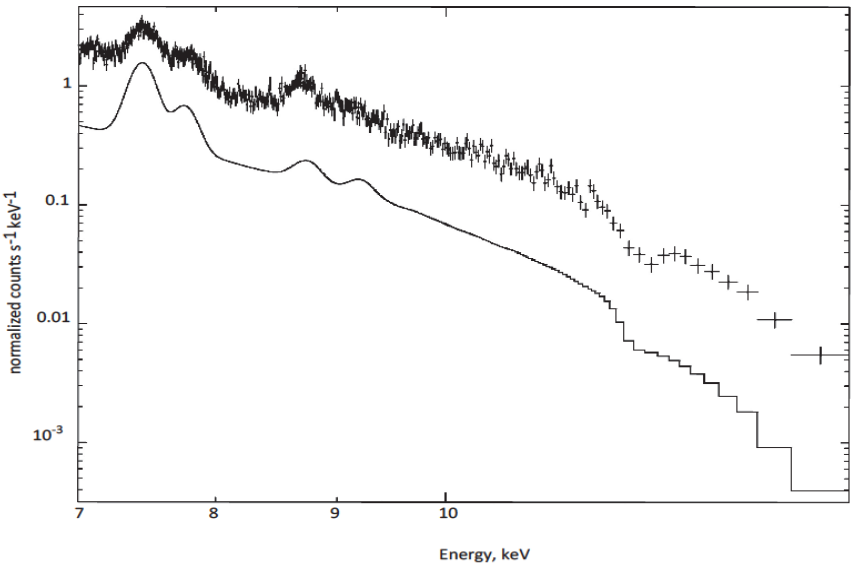

Figure 1. The observed spectum of SS 433 and the model of multi-temperature cooling jet spectrum (below).

We suggest that the additional radiation comes from deep inner regions of the supercritical accretion disc funnel and it is reflected at the observed outer funnel walls. We apply the reflection model by Ross et al. (1999), Ross & Fabian (2005), where an incident power law radiation and ionization parameter in the reflecting gas are used. To restore the incident spectrum we divide the total observed range 0.5-12 keV into several ranges and fit the reflection spectrum in these ranges independently (Fig. 1-6).

Our model provides good fits for each of the energy ranges. The residual do not exceed two sigma with exception of several features. Ionization parameter ξ is the same for each energy range (~300), but the photon index of the incident power low radiation is various (1.4-2.0).

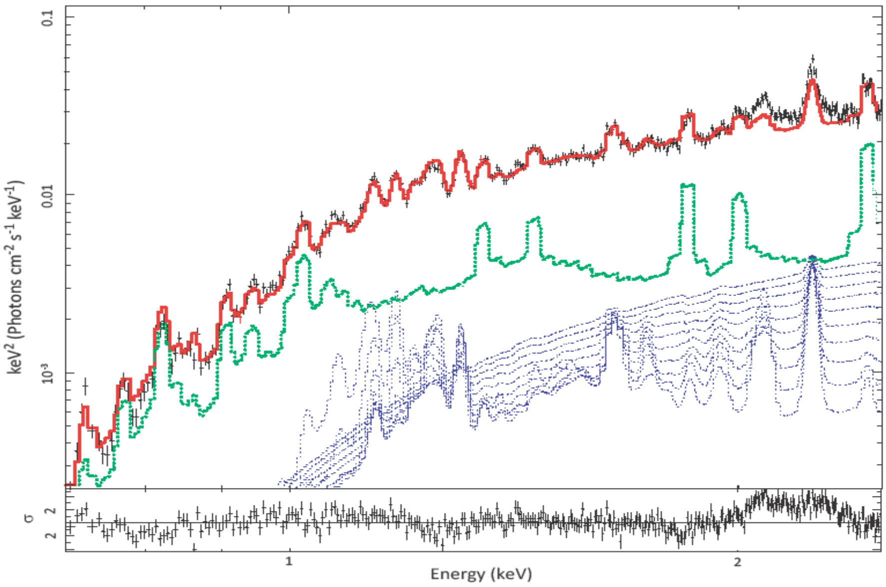

Figure 2. SS 433 spectrum in 0.7-2.5 keV range together with 10 jet model spectra (10 parts of the jet), the reflected spectra and the total model spectrum (thick line).

Fig. 2 shows SS 433 spectrum in 0.7-2.5 keV range together with multi-temperature cooling jet spectra (10 spectra of 10 parts of the jet), the reflected spectra (green) and the total model spectrum (red thick line). Residuals are shown in the bottom. Higher residuals around 2 keV have been noticed before by Brinkmann et al. (2005), they suggested a higher silicon abundance in the jets. We find the photon index of the incident radiation: Γ = 1.6.

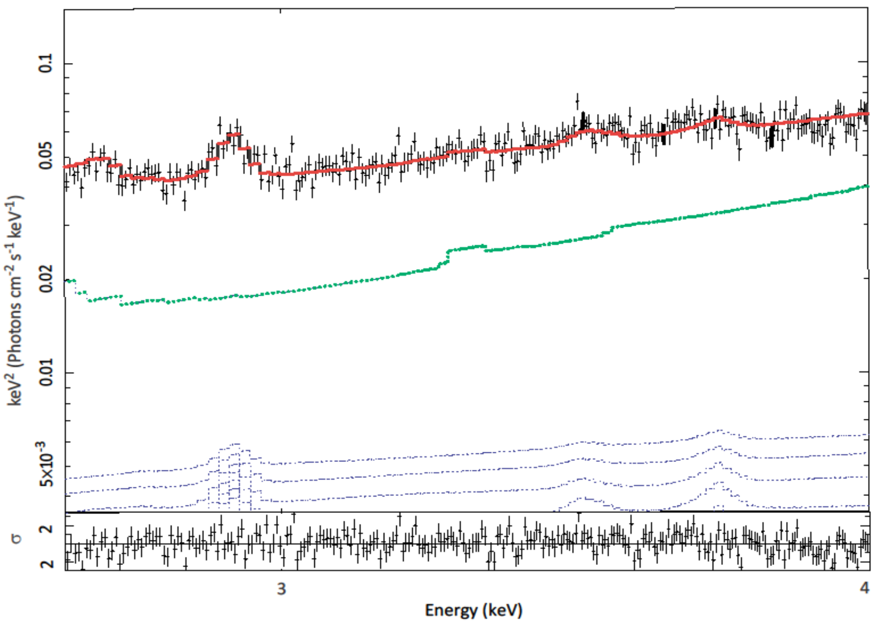

Figure 3. the same as in Fig 2. But in the 2.5-4.0 keV range.

Fig. 3 shows the same as in Fig 2. but for the 2.5-4.0 keV range. The photon index derived is 1.4. In Fig. 4 there is an emission line at ~5.7 keV. It is iron line of the receding jet, the receding jet radiation was not considered in our jet model. Photon index in this range equals to 1.9.

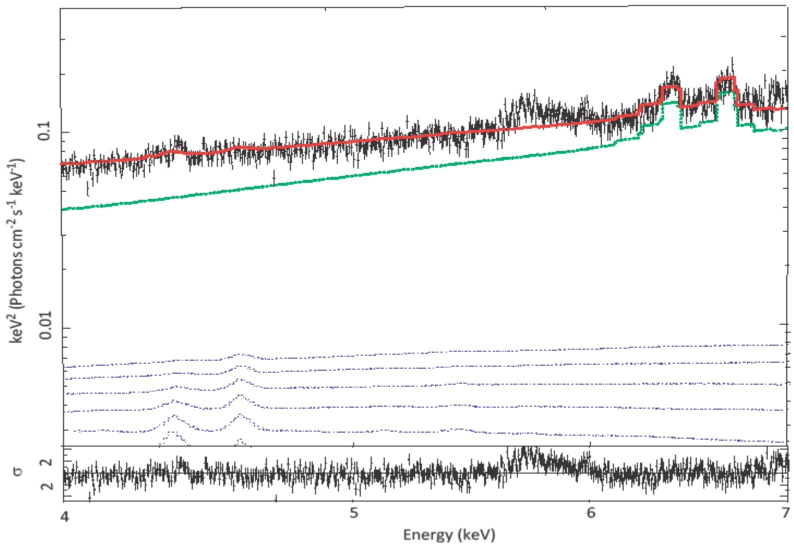

Figure 4. The same as in Fig 2. but in the 4.0-7.0 keV range.

In the 7.0-12.0 keV range presented in Fig. 5 the photon index of the incident radiation is 2.0. The strong discrepancy at ~8.7 keV is the "nickel problem" (Brinkmann et al. 2005). It can be eliminated by increasing the nickel abundance up to 8 times.

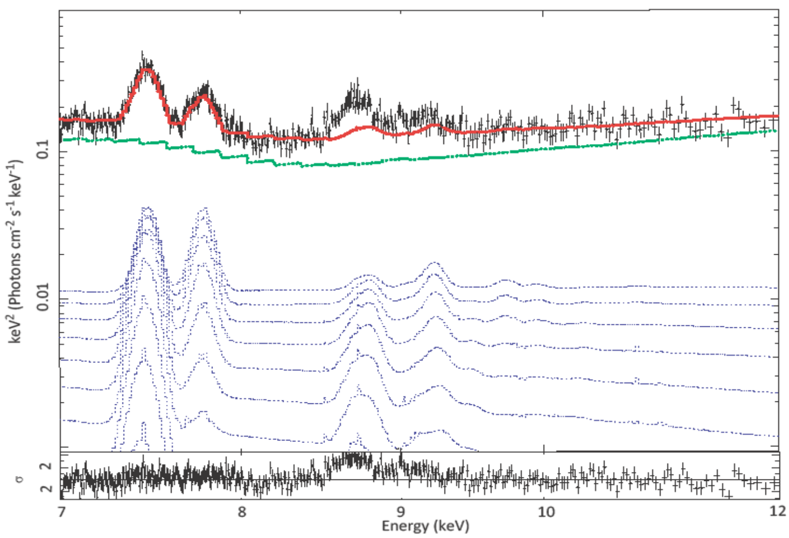

Figure 5. The same as in Fig. 2 but in the 7.0-12.0 keV range.

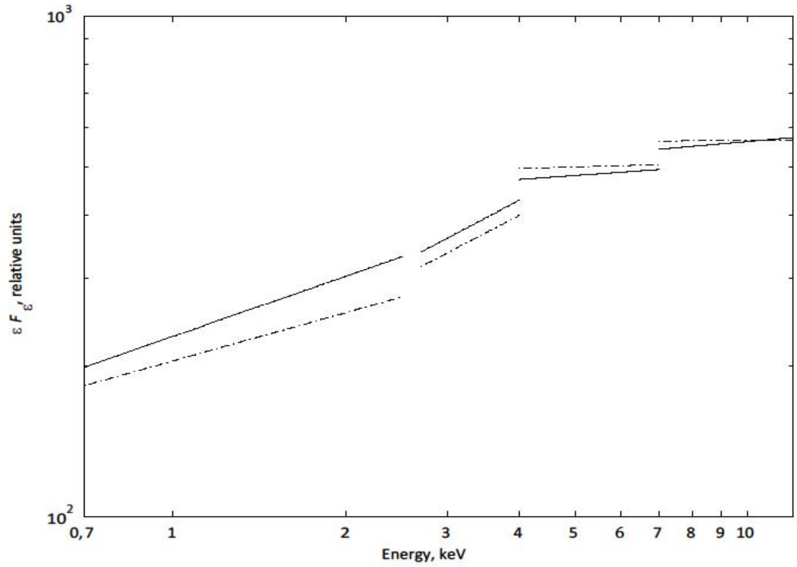

Figure 6. The restored spectrum of incident radiation derived from the spectral fits in precessional phases 0.0 (solid lines) and 0.8 (dashed lines).

We find that the reflected (Fig. 6) spectral component dominates (~70%) in the total spectrum in high energy range (7.0-12 keV). The incident radiation total spectrum is flat as it is expected in supercritical accretion discs and observed in Ultraluminous X-ray Sources (Stobbart et al., 2006, Poutanen et al., 2007). Using the ionization parameters derived we estimate a low limit of the intrinsic X-ray luminosity of the incident radiation exposing the observed gas as $L_x > 10^{38}$ erg/s.

References

[1] W. Brinkmann, T. Kotani, N. Kawai, *A&A.*, **431**, 575, 2005

[2] R.R Ross, A.C. Fabian, A.J. Young, *MNRAS*, **306**, 461, 1999

[3] R.R Ross, A.C. Fabian, A.J. Young, *MNRAS*, **358**, 211, 2005

[4] S.N. Fabrika, *Ap&SPR*, **12**, 1, 2004

[5] T. Kotani et al., *PASJ*, **48**, 619, 1996

[6] J. Poutanen et al., *MNRAS*, **377**, 1187, 2007

[7] R.K. Smith et al., *ApJ*, **556**, L91, 2001a

[8] R.K. Smith et al., *Spectroscopic Challenges of Photoionized Plasma, ASP Conf. Series,* **247**, 161, 2001b

[9] R.K. Smith, N.S. Brickhouse, *RMxAC*, **9**, 134, 2000

[10] A. Stobbart, T.P. Roberts, J. Wilms, *MNRAS*, **368**, 397, 2006