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Observing the strong gravity regime of accreting black holes with S -X

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Abstract. The X-ray reflection features of irradiated accretion disks around black holes enable us to probe the effects of strong gravity. We investigate to which precision the reflection signs, i.e. the iron K-line and the Comptonized hump, can be observed with S -X for nearby Seyfert galaxies. The simulations presented include accurate computations of the local reprocessed spectra and modifications due to general relativistic effects in the vicinity of the black hole. We discuss the impact of global black hole parameters and of the irradiation pattern of the disk on the resulting spectra as they will be detected by the S -X mission.

Key words. Black hole physics – X-rays: galaxies – Space vehicles: instruments

1. Introduction

The X-ray spectra of many accreting black holes are known to reveal relativistically modified reflection features, notably a fluorescent iron K-line complex (for a review see Reynolds & Nowak 2003) and a Comptonized hump (e.g. Lightman & White 1988). With its broad photon energy coverage the S -X satellite is particularly suited to observe such X-ray reflection spectra. In this proceedings note, we show that S -X will be able to distinguish X-rays being re-emitted at different radii of the innermost accretion disk.

We assume that the X-rays are produced by magnetic flares co-orbiting with the disk so that the reflection features originate in underlying orbiting spots. Detailed reflection spectra of such spots are modeled using the coupled radiative transfer codes T and N (Dumont, Abrassart, & Collin 2000; Dumont et al. 2003) and the relativistic effects are added applying the ray-tracing model KY (Dovčiak et al. 2004) inside . Our modeling procedure is described in detail in Goosmann et al. (2007). We assume a black hole with $M = 10^8\,M_\odot$ that is maximally spinning and that carries an accretion disk being in hydrostatic balance (before the flare goes off). We consider orbiting spots at the disk radii $R = 4\,R_{\rm g}$ and $R = 21\,R_{\rm g}$ ($R_{\rm g} = GM/c^2$). Simulated data are obtained for the "observed" spot emission at both radii using a modified version of the 1 model in and the currently available response matrices for the MPD and CZD detectors of S -X. The observation time is set to one Keplerian orbit in both cases and the flux rates are adjusted to an XMM-N observation of the Seyfert galaxy NGC 3516 (Iwasawa et al. 2004).

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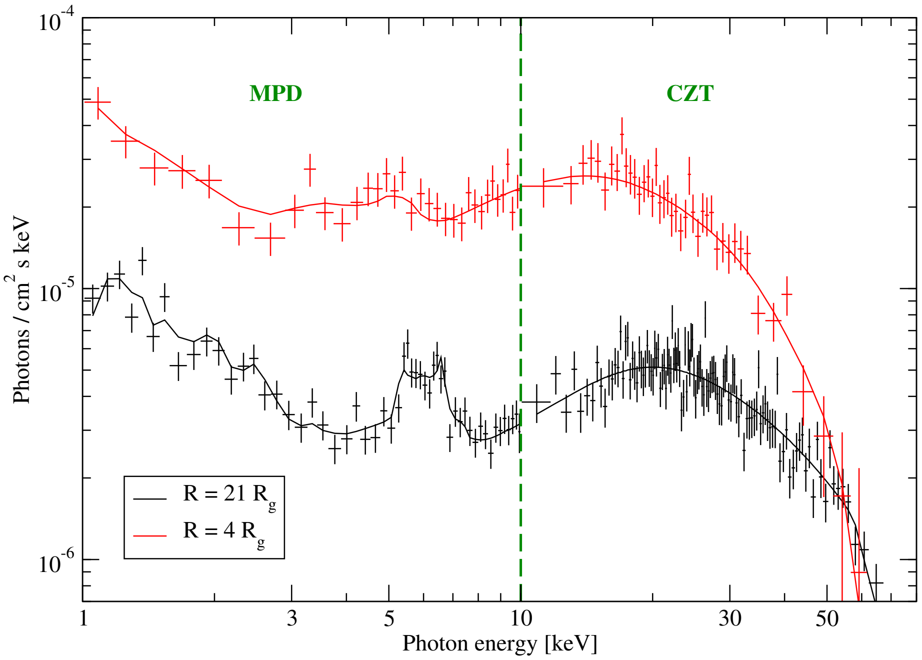

Fig. 1. Simulated MPD and CZD spectra of an orbiting flare spot at $R = 4\,R_g$ (top) and $R = 21\,R_g$ (bottom). The underlying models are shown as solid lines. The data sets contain a vertical offset for clarity.

In Fig. 1 the time-integrated spectra for both orbiting flares are plotted over the spectral range covered by the two detectors. While the overall spectral shape is similar for spots at both disk radii, the position and the shape of the reflection features differ significantly. At $R = 4\,R_g$ the impact of the gravitational redshift pushes the maximum of the Comptonized hump below 15 keV and the strong projected velocity gradient along the orbit almost entirely flattens the profile of the iron line complex. At $R = 21\,R_g$, on the other hand, the Compton hump is centered on 20 keV and the iron line profile is clearly visible showing a double horn. The data further suggests the appearance of separate soft X-ray emission lines below 3 keV.

For rapidly spinning black holes, it might thus be impossible to detect reprocessed emission from the innermost accretion disk (below $R = 6\,R_g$) in the iron line band, but the position of the Comptonized hump can give an alternative handle on the location of the reprocessing site. For larger disk radii, the fact that S -X observes both reflection features simultaneously puts important constraints on the emission radius and also on the applied reprocessing models.

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