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Variation of Fe Kα line equivalent width for orbiting spot around black hole

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Abstract. We study the variation of the line equivalent width, the ratio of the primary to the reflected continuum spectral component and hardness ratio. We assume the single flare-spot scheme taking all general relativistic effects into account. We find that both of the spectral ratios are significantly enhanced when compared with non-relativistic values. The equivalent width is enhanced only for very large inclination angles.

Key words. line: profiles – relativity – galaxies: active – X-rays: galaxies

1. Introduction

We examine the system of a black hole, a cold and neutral accretion disc and a co-rotating flare with the spot underneath. The co-rotating Keplerian accretion disc is geometrically thin and optically thick.

The flare is an isotropic stationary point source with power-law spectrum located in the corona very near above the disc. It co-rotates with the accretion disc. We also assume that a single flare dominates the intrinsic emission for a certain period of time. The spot represents a circular flare-illuminated part of the disc surface. Because the flare is very close to the disc, the spot does not extend far from below the flare. The local flux from the spot was computed by Monte Carlo simulations considering multiple Compton scattering and fluorescence in a cold slab. The local flux depends on the local incident and local emission angles, hence the flux changes across the spot. The local flux consists of only two components — the flux from the primary source (the flare) and the reflected flux from the spot. The latter one consists of the reflection continuum (with the Compton hump and the iron edge as the main features) and the neutral Kα and Kβ iron lines. No other emission is taken into account.

As far as the photon trajectories from the spot to the observer are concerned, all general relativistic effects — energy shift, aberration, light bending, lensing and relative time delays — are taken into account.

2. Spectral characteristics of the observed signal

In order to quantify the properties of the observed spectra we show several spectral characteristics (Fig. 1). We find that the EW does not much differ from its local value except for the Kerr case with observer inclination 85°.

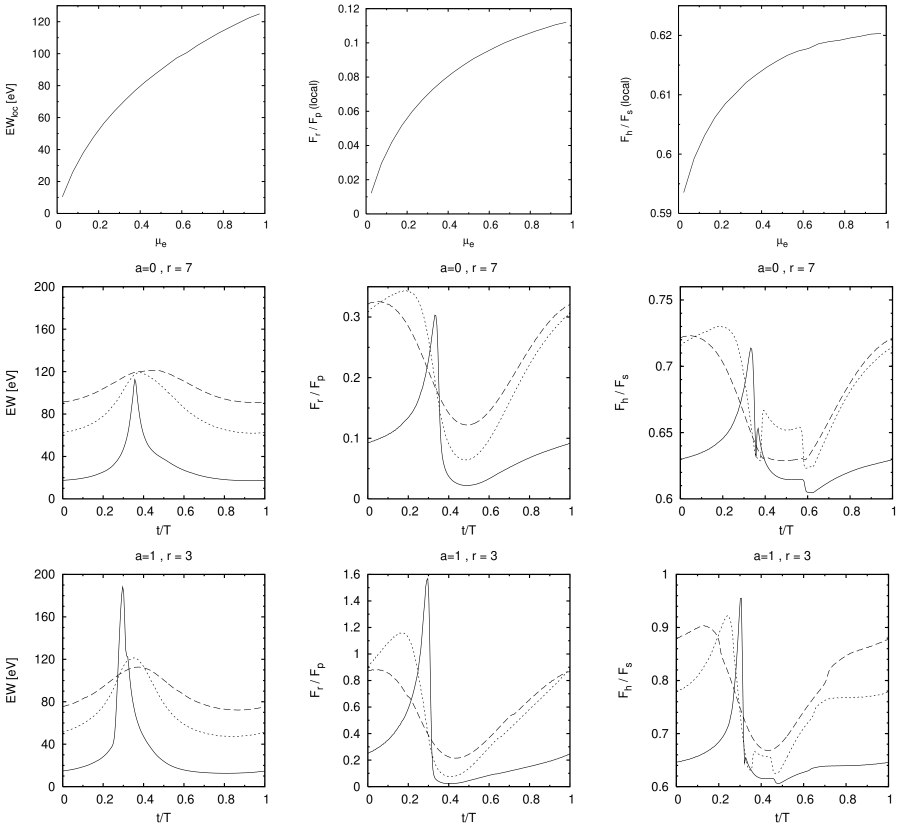

Fig. 1. The equivalent width (left), the ratio of the reflected to the primary flux (middle) and the hardness ratio (right column) in the non-relativistic (top), Schwarzshild (middle) and Kerr (bottom row) case for three observer inclinations — 30° (dashed), 60° (dotted) and 85° (solid line). Other parameters are height of the flare $h = 0.015\,GM/c^2$, orbital radius $r = 7\,GM/c^2$ in Schw. and $r = 3\,GM/c^2$ in Kerr case, the primary power-law photon index $\Gamma = 1.9$.

The observed ratio of the reflected flux to the primary flux is amplified when compared to the local one. The amplification is the highest in the Kerr case with $\theta_o = 85°$ — the ratio is increased by more than one order. Note, that in Kerr case for the inclinations 60° and 85° the ratio of the observed reflected flux to the observed primary flux is larger than unity, meaning the reflected component prevails the primary one.

To evaluate the hardness ratio we compared the fluxes in between 3–6.5 keV (soft component, F_s) and 6.5–10 keV (hard component, F_h). The hardness ratio is amplified when we compare it with the local hardness ratio. The amplification is the largest in Kerr case. The sudden increase in the observed hardness ratio around the time $t/T = 0.4$ is because the Fe Kα line passes from the soft to the hard component and back because of the Doppler shift.

We refer the reader to Dovčiak et al. (2007) for more details.

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References

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