Black Holes from Stars to Galaxies – Across the Range of Masses
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Polarization from an orbiting spot

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Abstract. The polarization from a spot orbiting around Schwarzschild and extreme Kerr black holes is studied. The time dependence of the degree and angle of polarization during the spot revolution is examined as a function of the observer's inclination angle and black hole angular momentum. The gravitational and Doppler shifts, lensing effect as well as time delays are taken into account.

Keywords. Black hole physics – accretion, accretion disks – polarization

1. Model

We assume Keplerian geometrically thin and optically thick disc around the Schwarzschild or extreme Kerr black holes. The spot is two-dimensional and it rotates together with the disc. We assume the spot does not change its shape during its orbit. Only the zero order photons have been taken into account here. Only the emission from the spot is considered; the decrease of polarization degree due to the disc and corona emission is not accounted for.

We apply three different models of local polarization. In the first two models the local emission is totally polarized either in the direction normal to the disc or perpendicular to the toroidal magnetic field. In the case of partial local polarization the observed one will decrease proportionally.

The last model of local polarization describe a more realistic situation: the spot is considered a part of the disc illuminated from a flare (considered to be a point source) above it and moving with Keplerian velocity. The photons from the primary source (the flare) are scattered in the disc. Some of them are eventually reflected in the direction to the observer. The scattering is handled in Compton multiple scattering approximation.

For further details on the model and approximations used we refer the reader to Dovčiak, Karas & Matt (2004, 2006). For an exciting application to Sgr A*, see Eckart *et al.* (2006).

2. Results

The results of our computations are presented on figures 1 and 2. The polarization degree (figure 1) decreases in all models mainly in that part of the orbit where the spot moves close to the region where the photons that reach the observer are emitted perpendicularly to the disc. The polarization angle (figure 2) changes rapidly in this part of the orbit. The decrease in observed polarization degree for the local polarization perpendicular to the toroidal magnetic field happens also in those parts of the orbit where the magnetic field points approximately in the direction of photon's motion. The polarization has more complicated behaviour for the more realistic model. One of the most interesting features is the peak in polarization degree for the extreme Kerr black hole

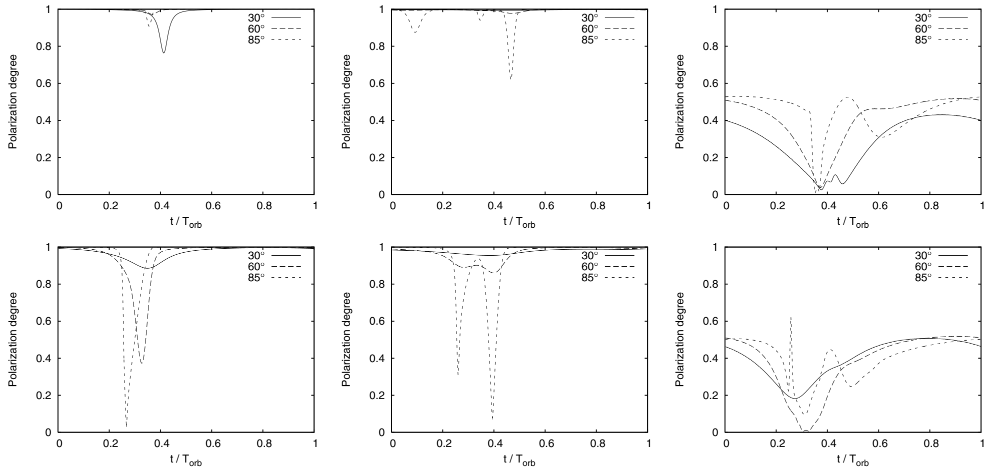

Figure 1. The time dependence of the polarization degree from a polarized orbiting spot in three different configurations of the local polarization vector — perpendicular to the disc, perpendicular to the toroidal magnetic field and Compton scattering approximation (from left to right) for Schwarzschild (top) and extreme Kerr (bottom) black holes and for three observer's inclination angles ($30°, 60°$ and $85°$). The spot is located at $r_{\rm s} = 7GM_\bullet/c^2$ for Schwarzschild and $r_{\rm s} = 3GM_\bullet/c^2$ for extreme Kerr black hole. The radius of the spot is approximately $\delta r = 0.87GM_\bullet/c^2$.

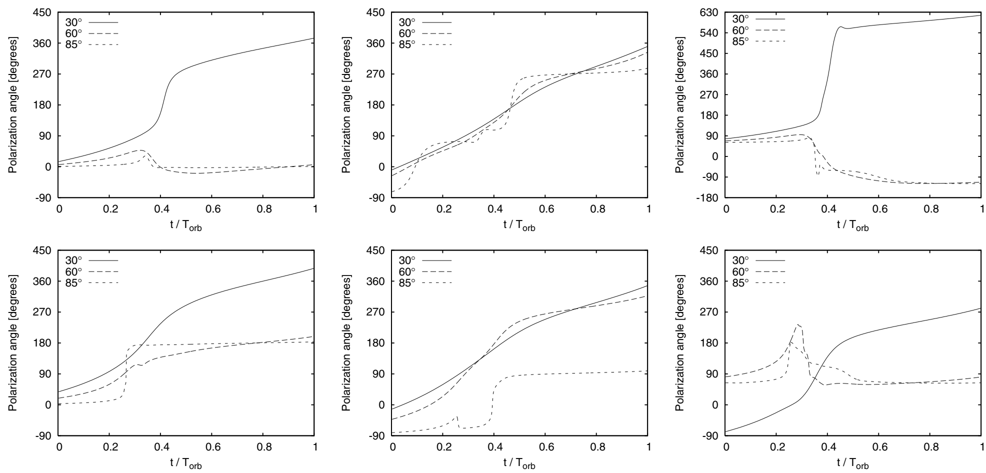

Figure 2. The same as in Fig.1 but for the polarization angle.

for large inclinations. It is due to the lensing effect when the emission with a particular polarization angle is enhanced. This is not visible for the Schwarzschild case because the spot is orbiting farther away from the centre.

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References

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