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Inclination dependence of the time-lag – photon-index correlation in BHXRBs and its explanation with a simple jet model

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It is widely accepted that the power-law X-ray spectra of black-hole X-ray binaries (BHXRBs) are produced by inverse Compton scattering in a corona, which is typically taken to be the hot inner flow around the black hole or the base of the jet. However, if a photon finds itself in the hot inner flow or the base of the jet, nothing prevents it from traveling higher up in the body of the jet. In other words, Comptonization in the hot inner flow and the base of the jet is, by necessity, followed by Comptonization in the body of the jet, because the jet is fed by the hot inner flow and lies above and below the hot inner flow. Over the years, we have demonstrated with a simple jet model that Comptonization in the body of a jet can explain not only the spectrum from radio to hard X-rays, but also the evolution of the photon index and the time (phase) lags as functions of Fourier frequency, the correlation between time lag and photon index (in Cyg X-1, in GX 339-4, and in the class of BHXRBs as a whole), and the correlation between time lag and cut-off energy in GX 339-4. Here we demonstrate observationally that the time-lag –photon-index correlation is different for systems with different inclinations. We also demonstrate theoretically, with Comptonization in the jet, that the same jet model reproduces nicely the inclination dependence of the correlation. Photons escaping the jet at different viewing angles obey different time-lag –photon-index correlations. The time lag is due to the random walk of the photons in the body of the jet.

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