A Model for High Frequency Quasi-periodic Oscillations from Accreting Black Holes

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Outline

- Motivation
- Ray-tracing in Kerr metric
- Images of accretion disk
- Geodesic orbits of hot spots (“blobs”)
- Light curves, power spectra
- Conclusions

Recent RXTE observations show QPOs at commensurate frequencies with integer ratios

Remillard et al. (2002)

Photons are ray-traced backwards in time from a distant observer through a finite-thickness computational grid.

Monochromatic line emission from the disk produces a relativistically redshifted image

$a/M = 0 \quad i = 60^o$

$a/M = 0.95 \quad i = 60^o$

Light curves are calculated by integrating emission from hot spots orbiting along geodesic orbits

$$e \equiv \frac{r_{max} - r_{min}}{r_{max} + r_{min}} = 0.09 \quad R_{ISCO} = 4.23M \quad \nu_\phi = 3\nu_r$$

The power spectrum of the X-ray light curve shows the characteristic coordinate frequencies of the hot spot orbit

$$a/M = 0.5 \quad i = 60^o \quad M = 10.3 M_\odot$$

$$\nu_\phi = 276\mathrm{Hz} \qquad \nu_r = 92\mathrm{Hz}$$

As the hot spot is sheared into an arc, QPO power in the higher harmonics is significantly reduced

Conclusions and future work

- We integrate the equations of motion in the Kerr metric to model the X-ray emission from geodesic particles in an accretion disk
- By calculating light curves from hot spots orbiting on geodesics, we gain insight into the features of high frequency QPO power spectrum
- The hot spot model is a powerful building block for more detailed models of dynamic accretion disks