VARIABILITY OF BLACK HOLE ACCRETION DISKS

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Abstract. We consider two forms of variability in black hole accretion disks: harmonically oscillating modes trapped near the disk inner edge, and noisy fluctuations throughout the entire disk. We apply the former to AGN disks, and the latter to the X-ray power spectra of GX339-4.

Key words: accretion disk, harmonic oscillations, X-ray power spectra, GX339-4

The mechanism governing harmonic oscillations in a disk is similar to that governing the g-modes of helioseismology, accept that the bouyancy frequency is replaced by the epicyclic frequency (*i.e.* angular momentum conservation). The modes, which are trapped near the epicyclic frequency maximum near the disk inner edge, oscillate predominantly in the vertical direction, have radial extents on the order of $2\ GM/c^2$, and have frequencies on the order of $0.03\ c^3/GM$ (a period of 10^6 seconds for $10^9\ M_\odot$). Detailed discussion of these modes can be found in [1, 2]. We recently have considered the stochastic excitation of these modes by turbulence, and we have made simple estimates of the resulting disk luminosity fluctuations [3]. For AGN parameters, R-band modulation may be on the order of several tenths of a precent, and UV modulation may be several percent. Observed mode periods are tens of days.

To explain the X-ray power spectra of galactic black hole candidates, we have constructed a simple kinematic model of accretion disk variability which is based upon viscous and thermal instabilities [4]. We assume local, exponentially growing fluctuations that grow on either a viscous time scale, ${\tau_V}^{-1} \sim \alpha\mathcal{L}^2\ \Omega$, or a thermal time scale, ${\tau_H}^{-1} \sim \alpha\Omega$ ($\alpha \sim 0.1$ is the usual Shakura-Sunyaev α parameter, Ω is the local Keplerian rotation frequency of the disk, $\mathcal{L} \sim 0.1$ is the ratio of the disk luminosity to the Eddington luminosity). The viscous instabilities can be supressed by a mass loss from the disk, whereas the thermal instabilities can be supressed by an energy loss. The X-ray power spectra of GX339-4 in its very high state is modelled as a transition from viscous to thermal instabilities. This constrains the temperature and total energy of a stabilizing "wind", the energetics of which are found to be consistent with Compton cloud models of GX339-4. Furthermore, the computed X-ray power spectra is consistent with the observations.

References

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