The Accretion-Ejection Instability in X-ray Binaries

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Abstract. The Accretion-Ejection Instability (AEI), which can occur in magnetized disks near equipartition, is a good candidate to explain the low-frequency QPO in black-hole binaries. Here we present analytical work concerning the behavior of QPO frequency and the emission of Alfvén waves from the disk to the corona.

Keywords: Accretion, accretion disks - Instabilities - MHD Waves - Galaxies: jets

1. Introduction

The AEI is a spiral instability, similar to galatic spirals but driven by magnetic stress rather than self-gravity. It occurs in the inner region of an accretion disk threaded by a vertical magnetic field of the order of equipartition with the gas pressure. The spiral extracts energy and angular momentum from the disk, causing accretion, and stores them in a Rossby vortex at its corotation radius (see also the contributions of Tagger and Caunt, these proceedings). This vortex then leaks energy and angular momentum as Alfvén waves to the corona, where it can power a wind or a jet. For more details see Tagger,M.& Pellat,R. (1999).

2. QPO Frequency in Pseudo-Newtonian Potential

Relativistic effects change the rotation curve of the disk near the last stable orbit. They allow the existence of an Inner Lindblad Resonance (ILR) for the $m = 1$ mode. This changes the properties of the 1-armed spiral (best candidate to explain the QPO), and therefore its frequency.

We have studied, using a pseudo-newtonian potential, the properties of the instability when the disk inner radius r_{int} approaches the Last Stable Orbit at r_{LSO}. When r_{int} is large the QPO frequency varies as $\omega \propto r^{-3/2}$; but as r_{int} approaches r_{LSO} the correlation changes and becomes *positive* (the QPO frequency decreasing with a decreasing radius) when $r_{int} < 1.4 r_{LSO}$, *i.e.* when the $m = 1$ mode has an Inner Lindblad Resonance in the disk (Varnière,P. , Rodriguez,J. & Tagger,M., 2000). We consider this as a possible explanation for the positive correlation found (contrary to other sources) in GRO J1655 as shown in these proceedings and Rodriguez,J., Varnière,P.& Tagger,M. (2000).

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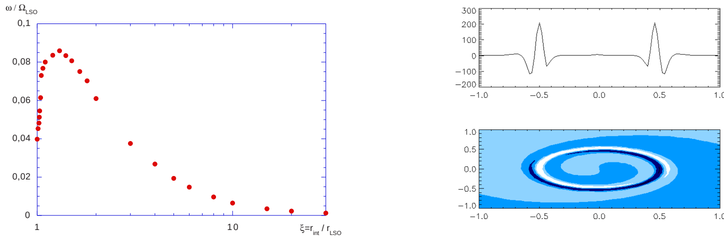

Figure 1. (left) the QPO frequency as a function of the disk inner radius r_{int}. The frequency-radius correlation is reversed when $r_{int} \lesssim 1.4 r_{LSO}$. (right) radial profile and spatial structure of the flux of Alfvén waves emitted to the corona.

3. Emission of Alfvén Waves

The Rossby vortex twists the footpoint of the field lines threading the disk. If the disk has a low density corona this twisting will be propagated upward as Alfvén waves. The energy and angular momentum extracted from the disk will thus be transfered to the corona where they can power a wind or jet. We study this with a variational form

$$F = [\text{energy of the waves}] + i \ \ [\text{outgoing spiral} + \ \text{vortex} \\ + k_z \ \text{Alfvén Waves}]$$

where imaginary terms correspond to amplification or damping of the instability. From the numerical solution we compute the flux of the emitted Alfvén waves. The result, plotted in Figure 1, shows that it peaks at the corotation radius, where the Rossby vortex is localized.

4. Conclusions

The frequency of the AEI, and its variations with the disk inner radius, make it a very good candidate to explain the “ubiquitous” QPO. The accretion energy and momentum extracted from the disk are propagated to the corona as Alfvén waves.

References

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