Dynamics of the Innermost Accretion Flows Around Compact Objects: Magnetosphere-Disk Interface, Global Oscillations and Instabilities

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Abstract

We study global non-axisymmetric oscillation modes and instabilities in magnetosphere- disk systems, as expected in neutron star X-ray binaries and possibly also in accreting black hole systems. Our two-dimensional magnetosphere-disk model consists of a Keplerian disk in contact with an uniformly rotating magnetosphere with low plasma density. Two types of global overstable modes exist in such systems, the interface modes and the disk inertial-acoustic modes. We examine various physical effects and parameters that influence the properties of these oscillation modes, particularly their growth rates. The interface modes are driven unstable by Rayleigh-Taylor and Kelvin-Helmholtz in- stabilities, but can be stabilized by the toroidal field (through magnetic tension) and disk differential rotation (through finite vorticity). General relativity increases their growth rates by modifying the disk vorticity outside the magnetosphere boundary. The interface modes may also be affected by wave absorption associated with corotation resonance in the disk. In the presence of a magnetosphere, the inertial-acoustic modes are effectively trapped at the innermost region of the relativistic disk just outside the interface. They are driven unstable by wave absorption at the corotation resonance, but can be stabilized by modest disk magnetic fields. The overstable oscillation modes studied in this paper have characteristic properties that make them possible candidates for the quasi-periodic oscillations observed in Galactic X-ray binaries.