Spectroscopy of Quasi-Periodic Oscillations in the Low-Mass X-ray Neutron Star Binaries

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Precise measurements of the frequencies of the two simultaneous kiloHertz quasiperiodic oscillations (kHz QPOs), ν_K and ν_h, in the atoll source 4U 1728-34 carried out by Mendez & van der Klis (1999) cast additional doubts about the validity of the simple beat-frequency interpretation and some of the modifications introduced to explain the results of the varying $\Delta\nu = \nu_h - \nu_K$. A new model (Osherovich and Titarchuk 1999, Titarchuk and Osherovich 1999) explains the variation of $\Delta\nu$ suggesting that ν_h is the upper hybrid frequency of the Keplerian oscillator under the influence of the Coriolis force. Such an oscillator has two branches characterized with high frequency ν_h and with low frequency ν_L. The frequency ν_L depends strongly on the angle δ between the normal to the neutron star disk and $\mathbf{\Omega}$ - the angular velocity of the magnetosphere surrounding the neutron star. In the lower part of the QPO spectrum, this model identifies the frequency of radial viscous oscillations $\nu_{\rm v}$ and the break frequency ν_b, which is associated with the diffusive process in the transition region (the innermost part of the disk). According to this model, all frequencies (namely ν_h, ν_L, ν_b and $\nu_{\rm v}$) have specific dependences on ν_K. This paper focuses on the verification of the predicted relations. For two sources, namely Sco X-1 and 4U 1728-34, we present a comprehensive classification of QPO within the framework of this model. For the source 4U 1728-34, the best theoretical fit is obtained for $\delta = 8.3 \pm 1^o$, which is slightly larger than $\delta = 5.5 \pm 0.5^o$ previously found for Sco X-1. In addition, we verify the theoretically derived power law relation $\nu_b \propto \nu_{\rm v}^{1.61}$ using recent observations of other atoll and Z-sources.