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A MODEL FOR THE KHZ QPO IN NEUTRON STAR BINARIES

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Abstract. Twin quasi-periodic oscillations have been observed in the emission spectrum of neutron star binaries. The models that have been proposed do not succeed to explain the frequency difference between the two kHz QPO, which is close but distinct from the rotation frequency of the neutron star. I will present a new model based on the dynamics of the gas trapped in the neutron star magnetosphere.

1 Introduction

Neutron star binaries are at the center of numerous investigations since they are the laboratory of extreme physics such as high magnetic field and strong gravity. These extreme conditions can be explored thanks to the X-ray emission of the accretion disk of the neutron star. The millisecond variability is one of the key-points of this emission since it originates in the inner part of the disk exposed to the stronger gravitational field.

The kHz quasi-periodic oscillations have been widely studied since their discovery in 1996 by the RXTE satellite. Various theoretical models have been proposed, but none of them was really convincing. Here we present a new model for the kHz QPO in neutron star binaries, based on the dynamics of the gas in the inner part of the accretion disk.

2 Observations and first models

2.1 Observations

Twin kHz QPO have been discovered in low-mass X-ray binaries containing a low magnetic field neutron star at diverse X-ray luminosities. Here is an example of such observations:

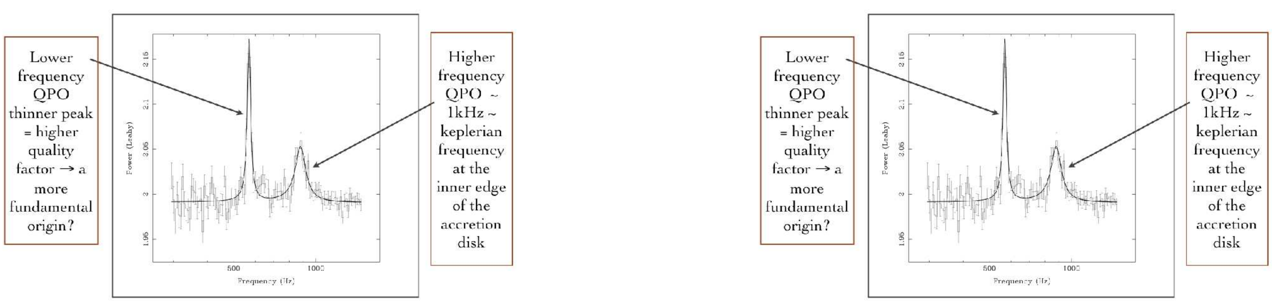

Fig. 1. *Left:* Power spectrum of a neutron star binary showing twin kHz QPO (Mendez et al., 1998) *Right:* Variation of the peaks separation as a function of the lower QPO frequency in 4U 1728-34 (Mendez & van der Klis, 1999)

One interesting point of twin QPO is that for the same neutron star binaries, their frequencies may evolve but the difference between the two peaks $\Delta\nu$ is constant and close to the rotation frequency of the neutron star for a wide range of variations of ν.

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2.2 Firsts models

After the discovery of the twin kHz QPOs, their intrinsic fundamental nature has been suggested and different models have been proposed. Two main classes of models can be distinguished: those based on a beat frequency (van der Klis, 2000) and the relativistic precession models (Stella & Vietry, 1999). None of them were fully convincing and twin QPO are still not clearly understood.

3 A model based on the dynamics of a magnetospheric disc

In the model presented here, we assume that the lower frequency is the keplerian frequency at the inner edge of the keplerian disk: this is a fundamental frequency much better adapted to explain the higher quality factor of the lower QPO. We then seek to explain the higher frequency QPO by the presence of a warped disk in the neutron star magnetosphere.

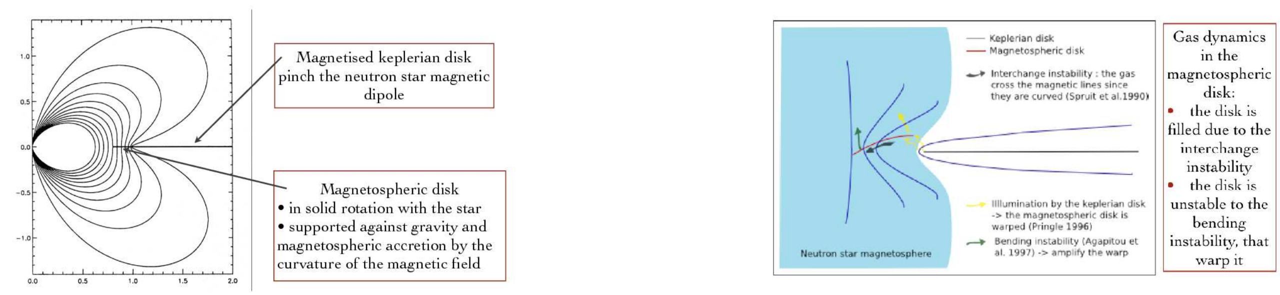

Fig. 2. *Left:* Geometry configuration of the model (Lepeletier & Aly, 1998) *Right:*

The dispersion relation of the bending instability can be written in this magnetic configuration:

$$(\omega - m\Omega_*)^2 = \Omega_K^{d2} + \frac{r(\Omega_K^2 - \Omega^2)}{B_z}\frac{\partial B_z}{\partial r} + \frac{2B_r^2}{\Sigma}|k| + \frac{L}{\Sigma d} + i\frac{L}{\Sigma}|k|, \tag{3.1}$$

with ω the frequency of the instability and $\frac{r(\Omega_K^2-\Omega^2)}{B_z}\frac{\partial B_z}{\partial r}$ depending on the position of the inner edge of Keplerian disk thus on Ω_K^d.

4 Conclusion

In this model the lower QPO is the fundamental one, it is the keplerian frequency at the inner edge of the accretion disk, and the higher frequency QPO is due to a bending instability in the magnetospheric disk. This model can explain the behaviour of the QPO frequency difference. However this model is still under development.

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