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Distribution of twin kHz QPOs in LMXBs

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Abstract. With kilohertz quasi-periodic oscillation (kHz QPO) sources in neutron star low mass X-ray binaries (NS-LMXBs) published up to now, we analyze the centroid frequency (ν) distribution of twin kHz QPOs. We find that Atoll and Z sources show the similar distributions of ν_1 and ν_2, which indicate that twin kHz QPOs may be the common property of NS-LXMBs and have the similar physical origins. The mean values of ν_1 and ν_2 in Atoll sources are higher than those in Z sources, and we consider that this may because the QPO signals are sheltered by the thicken accretion disk or corona in Z sources. The maximums of ν_2 in both Atoll and Z sources are the same order as the Keplerian orbital frequency of the NS surface, so kHz QPOs could occur near the NS surface.

Keywords. X-rays: binaries, stars: neutron, accretion, accretion disks

1. Introduction

Twin kHz QPOs in NS-LMXBs (Liu *et al.* 2007) often occur in pairs and were discovered in both Atoll and Z sources (van der Klis 2000,2006). They have rather coherent statistical behaves and this phenomenon is a powerful tool to probe the physical process in compact stars (van der Klis 2006,2008, Belloni *et al.* 2007, Barret *et al.* 2011, Méndez 2006).

The kHz QPOs are peaks superposed on the noise in the power density spectra (PDS), their profiles can be described by the Lorentzian function (van der Klis 2006):

$$P_\nu \propto \lambda/[(\nu-\nu_0)^2+(\lambda/2)^2], \tag{1.1}$$

where ν_0 is the centroid frequency, λ is the full width at half-maximum (FWHM). Twin kHz QPOs have two centroid frequencies (upper ν_1 and lower ν_2) corresponding to the two peaks, and ν_1, ν_2 show a power law relation (Zhang *et al.* 2006).

2. Results and Discussions

We collect 178 pairs twin kHz QPOs from Atoll sources and 155 pairs from Z sources. For Atoll (Z) sources, the ranges of ν_1, ν_2 are 127-979 Hz (56-902 Hz), 353-1253 Hz (229-1143 Hz), and the corresponding mean values are 653 Hz (536 Hz), 955 Hz (833 Hz), respectively. The maximums of ν_1, ν_2 in Atoll sources are 979 Hz (4U 1636-53), 1253 Hz (SAX J1750.8-2900) while the maximums in Z sources are 902 Hz (Sco X-1), 1143 Hz (Sco X-1). Fig. 1a and Fig.1b are the distributions of ν_1 and ν_2.

Atoll and Z sources show the similar profiles in ν_1, ν_2 distributions (see Fig. 1), so we consider that twin kHz QPO phenomena may the common property of NS-LMXBs and have the similar physical origins. The mean values and the maximums of ν_1, ν_2 in Atoll sources are higher than those in Z sources (see also Fig. 1), thus we think that these differences may result from the different accretion rates of the two types of sources: the accretion disk and corona of Atoll sources may be thin; on the contrary, the accretion disk and the corona of Z sources will be thickened by the radiation pressure and the

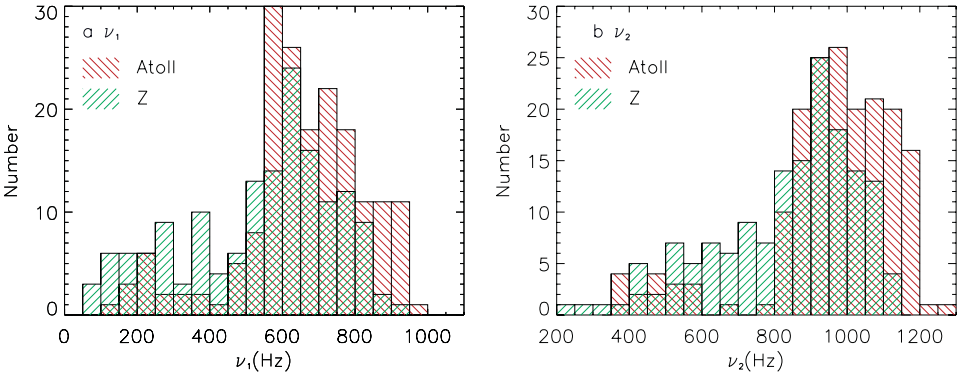

Figure 1. a (b) is the histogram of ν_1 (ν_2), the bin sizes are both 50 Hz.

fiercely interactive plasma because of high accretion rate, so the high frequency QPO signals in Z sources may be sheltered by the thickened disk or corona. The maximum of ν_2 in Atoll (Z) sources is around 1253 Hz (1143 Hz). They are the same order as the Keplerian orbital frequency of the NS surface (for the neutron star with radius 15 km and mass 1.4 $M_\odot$ (see Zhang 2004)), so kHz QPOs could occur near the NS surface.

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