Feeding Compact Objects: Accretion on All Scales
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Parameter constrain in neutron star by twin kHz QPOs

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Abstract. We use data on twin kHz QPOs and measured neutron star (NS) masses to test the relation between the lower (ν_1) and upper (ν_2) peak frequencies predicted with the MHD Alfvén wave oscillation model (AWOM) and the general relativistic precession model (GRPM). In the context of AWOM, the NS radius can be constrained from kHz QPO data and a measured NS mass.

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

1. Method

AWOM predicts the following relation between ν_1 and ν_2 (Zhang 2004, Zhang *et al.* 2006:

$$\nu_1 = 629(\mathrm{Hz})A^{-2/3}\nu_{2\mathrm{k}}^{5/3}\sqrt{1-\sqrt{1-(\frac{\nu_{2\mathrm{k}}}{1.85A})^{2/3}}}, \tag{1.1}$$

where $A = (m/R_6^3)^{1/2}$, m is the NS mass in $\mathrm{M}_\odot$, R is the NS radius and $R_6 = R/(10^6\mathrm{cm})$, $\nu_{2\mathrm{k}} = \nu_2/(1000\mathrm{Hz})$. With twin kHz QPO data (Belloni *et al.* 2002, 2005, van der Klis 2006, Psaltis *et al.* 1999) and measured NS masses (see Table 1), we compare the inferred NS radii with theoretical prediction. We note that in the context of AWOM, the NS radius follows from the kHz QPO frequencies and the NS mass (Zhang *et al.* 2007a,b, 2011, Zhang 2009).

In contrast, GRPM predicts (Stella & Vietri 1999):

$$\Delta\nu = \nu_{S,r} = \nu_{S,\phi}(1-6M/r)^{1/2}, \tag{1.2}$$

where $\Delta\nu = \nu_2 - \nu_1$, $\nu_{S,\phi} = \nu_2 = \nu_K = (M/4\pi^2 r^3)^{1/2}$, r is the coordinate distance and M is the mass of NS. With twin kHz QPO data, we derive NS mass values and compare them with measure results.

2. Results

The comparison results are shown in Table 1 and constrained radius of Cyg X-2 is shown in Fig. 1.

3. Conclusion

The inferred NS masses based on GRPM are consistent with the measured values of Cyg X-2, but inconsistent with those of SAX J1808.4-3658 and XTE 1820-30 (see Table 1). The inferred NS radii of the three sources based on AWOM are around $10-20km$ (see Table 1), which are consistent with the theoretical prediction for NS. Based on AWOM and the known NS mass value, one can constrain the radius of NS (see Fig. 1).

Table 1. Sources with the measured NS masses and derived parameters

Source(3)	Mass(measured) ($M_\odot$)	Mass(GRPM) ($M_\odot$)	A(AWOM)	Radius(AWOM) (km)
[1]SAX J1808.4-3658	< 1.4	2.80 ± 0.29	0.43 ± 0.01	< 19.54
[2]XTE 1820-30	$1.29^{+0.19}_{-0.07}$	1.87 ± 0.00	0.65 ± 0.00	$14.52^{+0.71}_{-0.26}$
[3]Cyg X-2	1.78 ± 0.23	2.04 ± 0.07	0.61 ± 0.002	16.89 ± 0.73
[4]Cyg X-2	1.5 ± 0.3	2.04 ± 0.07	0.61 ± 0.002	15.93 ± 1.06

[1]Chakrabarty & Morgan 1998, Elebert *et al.* 2009a; [2]Wang & Chakrabarty 2010, Shaposhnikov & Titarchuk 2004; [3]Orosz & Kuulkers 1999; [4]Elebert *et al.* 2009b

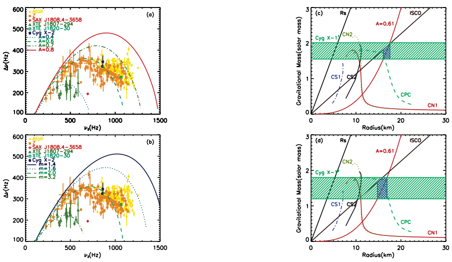

Figure 1. (a,b) show $\Delta\nu$ *vs.* ν_2 diagrams and the predicted curves based on AWOM and GRPM. (c,d) are the $M - R$ diagrams of NS. Five equation of state (EOS) curves are shown (see also Miller 2002).Rs is the Schwarzschild radius and ISCO is the innermost steady circular orbit. The shadow parts represent the mass and radius ranges of Cyg X-2 (see Table 1).

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