abstract

Type-I X-ray bursts occur on accreting neutron stars in binaries, where a layer of material - the ocean - is build up on its surface. If the thermal equilibrium in the ocean between heating by nuclear reactions and radiative cooling becomes unstable, a runaway process is triggered that quickly burns the ocean, emitting X-rays. Some of these thermonuclear bursts have a periodic signal, caused by a brightness asymmetry on the surface. The topic of this study is the mechanism behind these asymmetries, for which there are various models. It specifically focuses on the model by Cavecchi et al. (2011) that may apply to the sources XTE J1814-338 Strohmayer et al. (2003) and IGR J17480–2446 Cavecchi et al. (2011), whose burst oscillations have a stable frequency and are phase locked with their accretion powered pulsation, unlike other burst oscillations. The model’s main prediction is flame confinement by the magnetic field. To test this model, we look to an accreting neutron star called the Rapid Burster, that shows besides type-I also type-II X-ray bursts. The presence of the latter indicates that the RB has a strong enough magnetic field for the Cavecchi et al. (2011) model to apply and so we expect to see burst oscillations.

A search was done on 78 bursts of the Rapid Burster, using Fourier analysis to make power spectra of different segments of each light curve. As the shape of the light curve tends to boost powers at low frequencies, they require a more detailed analysis that was beyond the scope of this project. Therefore, powers below 50 Hz were ignored. Furthermore, combined spectra were made for each light curve segment by averaging the single burst power spectra. A similar search done by Fox et al. 2001, who reported a possible detection at 306.5 Hz. Our results show no significant detection. 99.9% confidence upper limits on the fractional amplitude were calculated for each single burst power spectrum and most of them range between ~ 3% rms and ~ 10% rms. These upper limits were used to constrain the geometry of the Rapid Burster, using the results of Muno et al. 2002. It was concluded there are several ways to explain the results: Firstly, there are no brightness asymmetries because the Cavecchi et al. (2011) does not work in general, or not for the RB. For example, it is possible its magnetic field is stronger than expected and this somehow affects flame confinement. There would also not be any bright spots if type-II burst models are mistaken and the magnetic field is too weak. Secondly, the RB rotates slowly and there is a signal below 50 Hz. There are theoretical arguments for this scenario Bagnoli et al. 2013, so this remains a topic for future research. Thirdly, our line of sight to the RB is unfortunately aligned with its rotational axis so brightness asymmetries do not result in a periodic signal. And finally, the RB’s rotational and magnetic axes are to a certain degree aligned. The upper limits on the fractional amplitude constrain the angle between them to be roughly below 5° for one bright spot, and below 30° for two.