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TIME LAGS OF THE KILOHERTZ QUASI-PERIODIC OSCILLATIONS IN THE LOW-MASS X-RAY BINARIES 4U 1608–52 AND 4U 1636–53

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We studied the time lags and the coherence of the X-ray light curves of the neutron star low mass X-ray binaries 4U 1608–52 and 4U 1636–53. These quantities are frequency-dependent measures of the time or phase delay and of the degree of linear correlation between two X-ray light curves in two different energies bands; they encode information about the size and geometry of the medium that produces them.

In fact, we studied the dependence of these time lags on the frequency of the kHz QPO and on energy, and to do so we divided our data in frequency and energy ranges. Our results (Figures 1 and 2) indicate that from light travel time arguments the region should be of order of 10 km. From the weak dependence on frequency, the geometry varies something about 1 km.

Lee, Misra and Taam proposed an inverse Comptonization model to explain the dependence on energy in which the time lags are produced because a corona of electrons and the source of soft photons oscillate coherently at the kHz QPO frequency. Besides explaining other timing properties, it provides a natural explanation for the opposition of the other kHz QPO time lags. The main conclusions are:

- This was the first study on the dependence of the time lags of the kHz QPOs upon the QPO frequency in a NS-LMXB (see also Barret);
- The lags of the lower and upper kHz QPOs are inconsistent with each other (soft and hard respectively);
- Regarding the dependence on energy, this was the first study in the case of the upper kHz QPO;
- We found that for this case the lags are consistent in being zero and independent on energy; the (soft) time lags of the lower kHz QPO show a significant trend in increasing from ~ 10 to ~ 100 μs, confirming with finer energy resolution previous results.

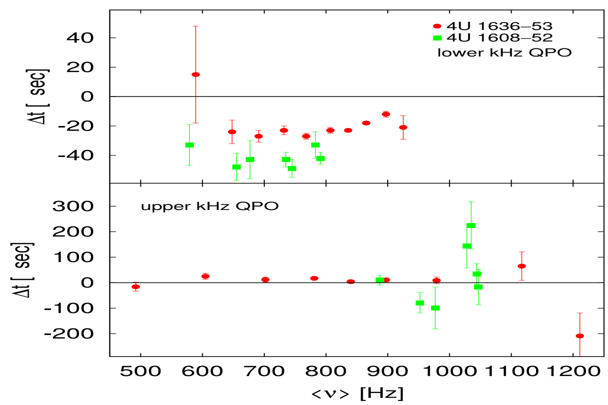

Fig. 1. Weak dependence on frequency; the lags of the lower kHz QPOs of both sources are soft (which means that the higher energy photons arrive first) while the time lags of the upper kHz QPOs are hard (meaning the opposite).

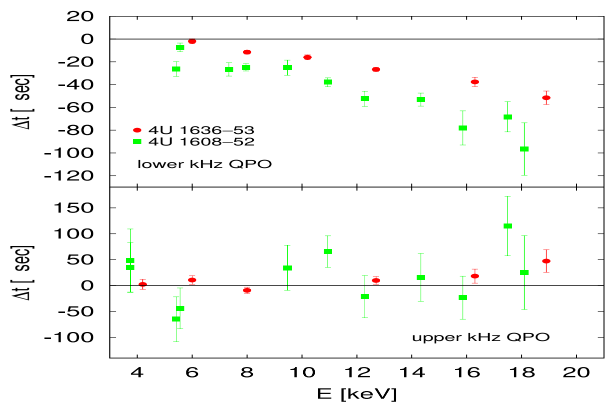

Fig. 2. The lower kHz QPO of both sources show a strong trend on energy; the upper kHz QPO of both sources show constancy.

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