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New results of the time lags in the QPO's of 4U 1636-53

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We present an analysis of the energy and frequency dependence of the Fourier time lags of the hectoHertz quasi-periodic oscillations (QPOs) and of the QPOs at the frequency at which the power density spectrum shows a break in the neutron-star low-mass X-ray binary 4U 1636–53, using a large data set obtained with the Rossi X-ray Timing Explorer.

We found that: (i) For the break frequency QPO: for low frequencies, in general the time lag is positive, but it is decreasing with increasing frequency, reaching zero lag at ˜ 20 Hz. Between 20 and 35 Hz there is a small fluctuation around zero, from where the time lags become positive again and increase slightly above zero up to 65 Hz. (ii) For the hHz QPO: we see that when the frequency is ˜100 Hz the time lag is negative, but it increases to zero already at ˜110 Hz, being consistent with this value up to 130 Hz from where it increases to 0.5 msec at around 140 Hz. From 140 Hz the time lag decreases sharply, being strongly negative for hHz > 220 Hz. (iii) We see no significant dependence of the time lags on energy for both QPOs studied here, but for the hHz there can be some weak sinusoidal dependence.

We compare these lags with our previous results for the lags of the kiloHertz QPOs in this same source and discuss possible scenarios for producing the lags in this system in the context of reflection off the accretion disc or up-/down-scattering in a hot medium close to the neutron star.

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