Mass and radius constraints for neutron stars from pulse shape modeling

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We present a method that can be used to constrain masses and radii of neutron stars. The method is suitable for accreting millisecond pulsars, where a rapidly rotating neutron star accretes matter from a relatively low mass companion star onto the magnetic poles of the neutron star. Because of the accretion, we observe radiation from two hot spots on the neutron star surface. This radiation is pulsating coherently at the spinning frequency of the neutron star. We model the exact shape of the pulses using Schwarzschild-Doppler approximation, which takes the general and special relativistic effects into account. An empirical model is used to describe the oblate shape of the star caused by the fast rotation. The spectrum of the radiation is obtained from an empirical model of Comptonization in which a fraction of photons in a seed blackbody spectrum is scattered into a power-law component.

The pulse profiles carry information about the mass and radius of a neutron star since e.g., the light bending and thus pulse shape depends strongly on the compactness of the star. Also many other physical parameters and observing angles affect the light curves. Therefore, we use Bayesian analysis and a novel Monte Carlo sampling method, called ensemble sampler, to obtain probability distributions for the different parameters, especially for the mass and the radius. To test the robustness of our method, we have generated synthetic data and fitted the pulse profiles to these. The synthethic data is as closely as possible resembling the real observations of SAX J1808.4 − 3658 observed by *RXTE*. The results of our samplings show that obtaining new constraints for radius and mass is possible. However, prior information obtained from polarization measurements may be used the get significantly tighter constraints.

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