Improved methods for modeling pulse shapes of accreting millisecond pulsars

Denis Leahy[1], Sharon Morsink[2], Coire Cadeaus[2]

[1]University of Calgary
[2]University of Alberta

ABSTRACT: Raytracing computations for light emitted from the surface of a rapidly rotating neutron star are carried out in order to construct light curves for accreting millisecond pulsars. These calculations are for realistic models of rapidly rotating neutron stars which take into account both the correct exterior metric and the oblate shape of the star. We find that the most important effect, comparing the full raytracing computations with simpler approximations currently in use, arises from the oblate shape of the rotating star. Approximating a rotating neutron star as a sphere introduces serious errors in fitted values of the star's radius and mass if the rotation rate is very large. However, for lower rotation rates acceptable mass and radius values can be obtained using the spherical approximation.

The full raytracing calculations are too time-consuming to be used for fitting observational data. Pulse shape fitting algorithms have been developed which include special relativistic effects, light-bending effects due to general relativity, and time-delays. Currently under development is inclusion of oblateness of the neutron star. As an application of the new algorithms, we fit the observed pulse shape of SAX J1808-3654, which was the first accreting neutron star to have detection of a millisecond pulse frequency. The effects of different physical effects is discussed by comparing fits with and without each effect. We find each of them causes a significant change to the conclusions derived about the emitting region and the derived mass and radius of the neutron star.

This work supported by the Natural Sciences and Engineering Research Council of Canada.