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Modeling Optical Light Curves and Radial Velocity Curves from Compact Binary Millisecond Pulsar Systems

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Compact binary millisecond pulsar systems contain a rapidly rotating neutron star, or pulsar, and a companion star. The pulsar wind contains high energy particles that can heat, or irradiate, the companion, and we can observe the effects of this in optical data of the companion. These systems can host the most massive pulsars and to accurately calculate their masses, we model the optical light curves emitted from the companions in these systems, along with their radial velocity curves and emitted spectra, to find the binary parameters of the systems. We use the binary modeling software ICARUS to model systems exhibiting a range of irradiation strengths. We implement a new Markov Chain Monte Carlo sampling algorithm that links multiple datasets for the same source to find changes in the system over multiple years. In one system, PSR J1622-0315, we find evidence for a supermassive neutron star of mass $2.3 \pm 0.4\,\mathrm{M}_\odot$ and a companion with low, but significant irradiation, and variable asymmetric heating from star spots.

We also systematically compare models of radial velocities with different weights for systems showing moderate and high amounts of irradiation. We use Balmer and MgI absorption lines to trace radial velocities from different regions of the companion to precisely bracket the center of mass radial velocity of each system. We perform simultaneous fits of the light curves and radial velocity curves of multiple systems to find more precise estimates of the their binary parameters.

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