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The Variable Redback PSR J2039-5617

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The gamma-ray source 3FGL J2039.6-5618 contains a periodic optical and X-ray source that was predicted to be a ''redback" millisecond pulsar binary. However, without the detection of pulsations, this identification remained inconclusive. Using new optical observations to refine the orbital ephemeris, we searched for gamma-ray pulsations with 10 years of Fermi-LAT data using the Einstein@Home volunteer computing system. The successful discovery of gamma-ray pulsations confirms the redback prediction, and makes this source one of just a handful of millisecond pulsars that have been first identified through their gamma-ray pulsations, instead of their radio pulsations. I will describe how this discovery provides the missing puzzle piece required to interpret a wealth of multiwavelength data. Combined with optical spectroscopy and light curve modelling, timing the pulsar's orbit provides a new pulsar mass measurement. We detect long-term variability in both the optical light curve and the pulsar's orbital period, suggesting magnetic activity in the companion star may play an important role in the behaviour of this system. We also find a significant enhancement of the pulsed gamma-ray flux around the pulsar's superior conjunction, which we interpret as up-scattering of the companion's optical emission by leptons accelerated by the pulsar. Together, these phenomena make this system an important new specimen for understanding a wide range of neutron star astrophysics, from pulsar wind and emission mechanisms, to the evolution of pulsar binaries.

Author: CLARK, Colin

Co-authors: Mr NIEDER, Lars (Albert Einstein Institute, Max Planck Institute for Gravitational Physics); Dr CORONGIU, Alessandro (INAF - Osservatorio Astronomico di Cagliar); Dr MIGNANI, Roberto (INAF - Istituto di Astrofisica Spaziale e Fisica Cosmica Milano); Dr VOISIN, Guillaume (Jodrell Bank Centre for Astrophysics, University of Manchester); ON BEHALF OF THE FERMI-LAT COLLABORATION

Presenter: CLARK, Colin

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