

PRESS NOTE

**National Centre for Radio Astrophysics
Tata institute of Fundamental Research, Pune**

Indian astronomers uncover the properties of a rare type of pulsar

A group of astronomers from the National Centre of Radio Astrophysics, TIFR, Pune, led by Ankita Ghosh, a Ph.D. student at NCRA, and her supervisor Prof. Bhaswati Bhattacharyya of NCRA, revealed a rare type of millisecond pulsar (MSP) named PSR J1242-4712 using the upgraded Giant Metrewave Radio Telescope (uGMRT). The team found that the millisecond pulsar revolves around a very low-mass companion star weighing one-tenth the mass of our sun. This study shows that this MSP is in the process of destroying its companion. This research mostly focuses on how this system orbits and moves around each other and also about the special nature of the system.

Pulsars are like cosmic lighthouses, beaming out radio signals as they spin extremely fast, as much as several hundreds of rotations around their axis in a second. Some of these pulsars are rotating hundreds of times per second – those are millisecond pulsars (MSPs). MSPs are considered to be older neutron stars that got a boost in the spin from a nearby star by accreting material and angular momentum from its companion, spinning faster and faster in the process, leaving a lightweight companion.

In some of the MSP systems, the pulsar and the companion star are in a very close orbit. The intense energy spewing from the MSP can strip away its companion's material which can block the radio signals from the pulsar causing an eclipse. This interaction creates MSPs with the super lightweight companions, dubbed “spider” MSPs. As they thought to destroy their companion, the two subcategories of spider MSPs are named: “black widows” with tiny companions (with less than one-20th the mass of our Sun) and “redbacks” with slightly heavier ones. Ankita Ghosh and the team from NCRA studied an MSP, J1242-4712, which was also discovered with GMRT in 2016 by Bhaswati Bhattacharyya and the team. This particular MSP spins so fast that it completes a full rotation around its axis in just 5.31 milliseconds.

Using observations from the uGMRT at 400 MHz and 650 MHz, the team managed to nail down some precise timing details for this pulsar. Pulsar timing is like monitoring a celestial clock, tracking its regular pulses of radio waves. They might spin up or slow down slightly like a clock losing or gaining a few seconds over time. Pulsar timing involves carefully measuring these tiny changes. This can unveil mysteries, from extreme physics to the relationships between the pulsar and its companion. Ankita Ghosh and the team got an

impressive timing accuracy of 2.4 microseconds for the PSR J1242-4712. They also figured out that PSR J1242-4712 is locked in with a companion star weighing 0.08 times the mass of our sun, and they complete a full rotation around each other once every 7.7 hours. This MSP also briefly eclipses when it is nearest to its companion in orbit, confirming that PSR J1242-4712 is a “spider MSP” with a sub-class of either “redback” or “black widow”. However, unlike most “redbacks”, J1242-4712 doesn't have an optically visible companion star, but, it has a more dynamic orbit and heavier companion which closely resembles “redbacks” compared to “black widows”. Its characteristic age has been estimated to be 4 billion years.

In a nutshell, J1242-4712 is straddling the line between “black widows” and “redbacks”. Positioned within an ambiguous region between the conventional “black widow” and “redback” characteristics, this system emerges as a noteworthy and unusual “redback” variant sharing properties of both black widows and redbacks. Findings from this study suggest a category of millisecond pulsars that share properties bridging these two subclasses of spider binary systems.

The research was published in the *Astrophysical Journal* (<https://iopscience.iop.org/article/10.3847/1538-4357/ad31ab>). The other members of this project are, Prof. Andrew Lyne from the Jodrell Bank Centre for Astrophysics, The University of Manchester; Prof. David Kaplan from the Center for Gravitation, Cosmology, and Astrophysics, University of Wisconsin-Milwaukee, USA; Prof. Jayanta Roy from NCRA; Prof. Paul Ray from Space Science Division, U.S. Naval Research Laboratory, Washington, DC; Prof. Benjamin Stappers from the Jodrell Bank Centre for Astrophysics, The University of Manchester; and three senior Ph.D. students Sangita Kumari, Subham Singh and Rahul Sharan from NCRA.

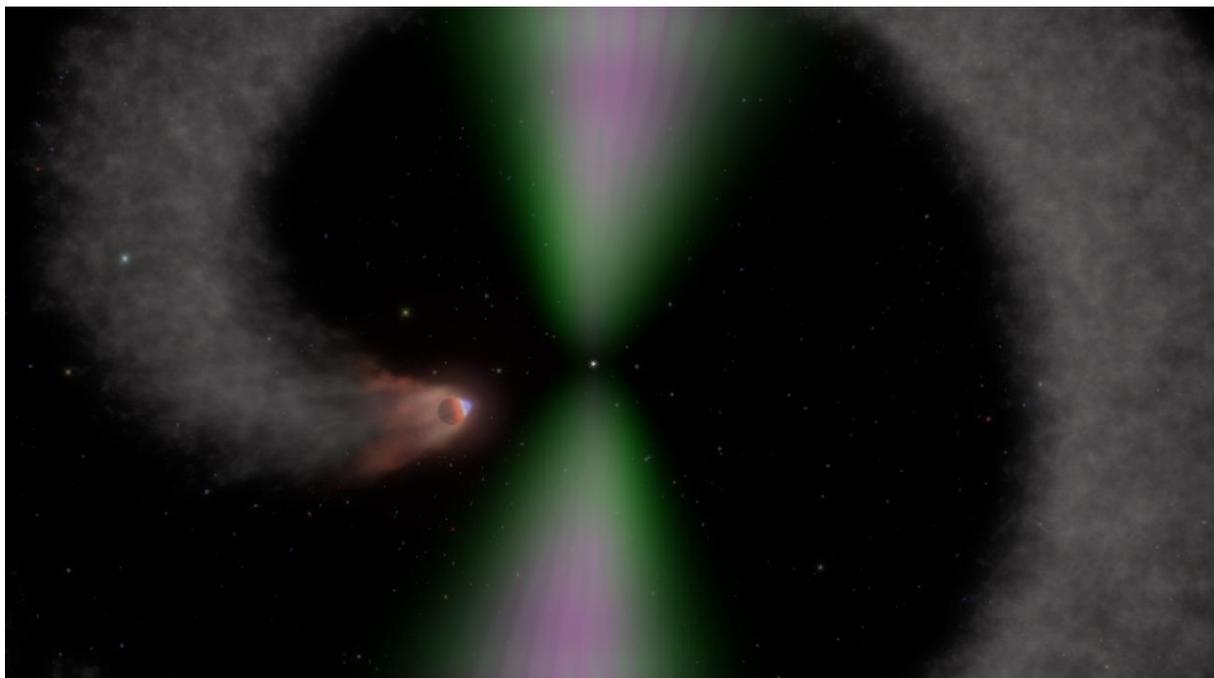


Figure1: Spider pulsar (at the center) destroying its companion. Image credit: NASA

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