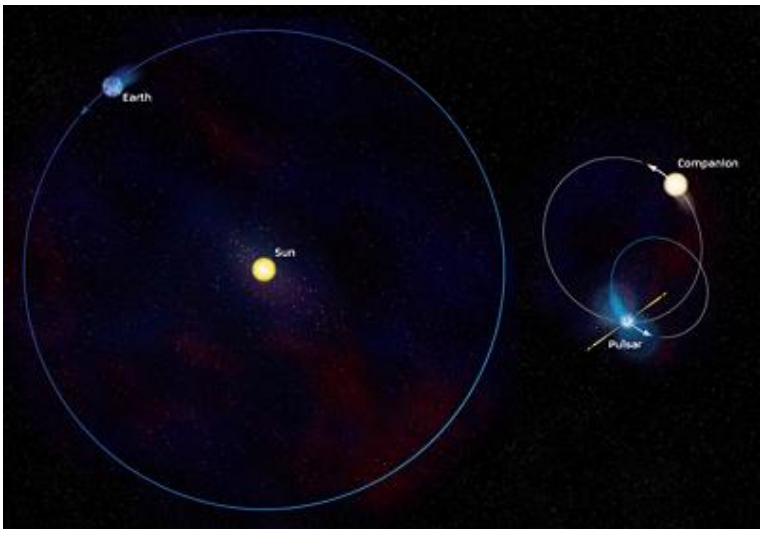
Eccentric pulsar system challenges theories of binary formation



A comparison of the orbits of the pulsar J1903+0327 and its possible sun-like companion star with the orbit of the Earth around the sun. The objects' sizes are not to scale. Bill Saxton, NRAO/AUI/NSF

An ongoing sky survey using the Cornell-managed Arecibo radio telescope in Puerto Rico has turned up a massive, fast-spinning binary pulsar with a mysterious elongated orbit, researchers say. The pulsar and its companion star challenge currently accepted views of binary pulsar formation and give researchers a new opportunity for understanding the fundamental properties of highly dense matter.

The discovery is reported today (May 15) in *Science Express*, the online site for the journal Science, by David Champion of the Australia Telescope.

The pair of objects is quirky in several ways, said Jim Cordes, professor of astronomy at Cornell and one of the paper's authors. The pulsar, JI903+0327, rotates once every 2.15 milliseconds, making it one of the faster-spinning among the known millisecond pulsars, or MSPs (pulsars that rotate once every 10 milliseconds or faster).

While about 50 MSPs have been identified in our galaxy, Cordes said, other MSPs in binary systems orbit in tight, precise circles. The JI903+0327 system's orbit, by contrast, is highly eccentric.

"These are [usually] the most perfect circles in the universe," said Cordes. "When we come across an object that has high eccentricity, it really stands out. We don't know of any other MSP like this."

The companion star itself is another anomaly: Apparently, it is a main sequence star (similar to our sun) rather than the more typical white dwarf or neutron star.

According to conventional scenarios for binary pulsar evolution, pulsars with slower spins are either isolated or, if in a binary, are likely to have been knocked into an eccentric orbit by the explosion of the supernova that created the pulsar. Faster spinning MSPs, on the other hand, have usually been "spun up" by momentum and matter accreted by their companion star's precursor -- and orbit in near-perfect circles.

Taken together, the newly discovered pulsar's fast spin, eccentric orbit and unusual companion require an alternate explanation -- possibly involving interaction with a third object or recent ejection from a globular cluster.

"In a globular cluster you've got all these other things happening -- collisions, other interactions … that

provide numerous pathways for formation," Cordes said.

Meanwhile, the pulsar's high mass (1.74 solar masses) could help physicists better understand how matter behaves in extreme conditions.

Astronomers first detected the JI903+0327 in October 2005 as part of Arecibo's Pulsar ALFA (Arecibo L-band Feed Array) or PALFA Survey, an ongoing sky survey using ALFA -- a system of detectors with seven feeds that enables researchers to image large swaths of sky. Follow-up observations of the pulsar and its companion star used Arecibo, the Robert C. Byrd Green Bank Telescope in West Virginia, the Westerbork Synthesis Radio Telescope in the Netherlands and the Gemini North Observatory in Hilo, Hawaii.

All data for PALFA, which began in 2004 and is one of three ongoing sky surveys using the ALFA receiver, are archived and dispensed by the Cornell Center for Advanced Computing for the international PALFA Consortium, which is chaired by Cordes.

Source: Cornell University