

## ASTRONOMY

# Neutron Oddball

A newly discovered neutron star doesn't behave like it's supposed to **BY MARK ALPERT**

Our galaxy is littered with the corpses of dead stars. At the end of their useful lives, the vast majority of the stars in the Milky Way shed their outer layers and shrink to white dwarfs, dense spheres about the size of Earth. But very massive stars explode in supernovae and leave behind even denser relics, called neutron stars, which are only 20 to 40 kilometers across but weigh more than our sun. (The most massive stars of all become black holes.) Since the 1960s astronomers have observed a wide variety of neutron stars, including madly rotating pulsars that sweep radio beams across the galaxy and x-ray binaries that devour material pulled from their companion stars. But last August researchers announced the discovery of perhaps the oddest neutron star yet, a lone x-ray emitter in the Ursa Minor constellation that does not seem to fit into any observed category.

Scientists have long been fascinated by neutron stars because their physics is so extreme. Their crushing gravity fuses electrons and protons into neutrons, and at the core the neutrons may break down to their constituent quarks. To better understand the formation and evolution of these bodies, some researchers have focused on isolated neutron stars (INS) that have moved away from the nebulous remnants of the supernovae that created them. Over the past decade astronomers have detected seven such objects that emitted x-rays observed by the German space telescope ROSAT but produced no radio beams like the ones generated by the rotation-powered pulsars. Dubbed "The Magnificent Seven" after the classic 1960 movie, the neutron stars were deemed to be relatively nearby (most of them less than 2,000 light-years

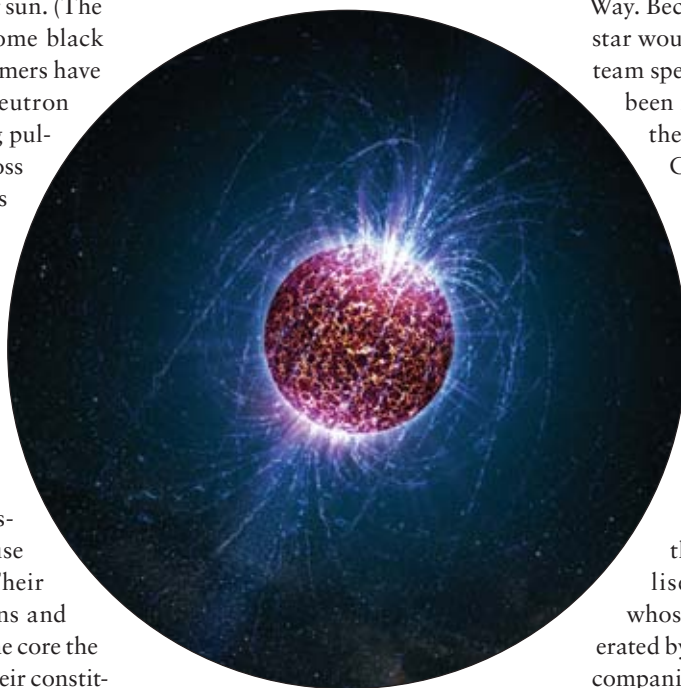
from the sun) and relatively young (probably less than a million years old).

In an effort to find additional INS objects, a team composed of Robert Rutledge of McGill University and Derek Fox and Andrew Shevchuk, both at Pennsylvania State University, identified another ROSAT x-ray source in a patch of sky where there were no ordinary stars. Clos-

the disk of the Milky Way. If one assumes that Calvera has the same characteristics as the other INS objects, then the neutron star must lie 25,000 light-years from Earth and 15,000 light-years above the galactic plane.

That position would put Calvera squarely in the galactic halo, the diffuse spherical region surrounding the Milky Way. Because it is unlikely that a neutron star would form in the halo, the research team speculated that Calvera might have been flung out of the galactic disk by the force of its violent birth. But if Calvera formed less than a million years ago, as the models predict, it would have had to fly out of the Milky Way at a blistering speed of more than 5,000 kilometers per second, which is far faster than any other neutron star.

This conundrum led the researchers to reconsider Calvera's classification in the INS category. They postulated that the object might instead be a millisecond pulsar, a neutron star whose rotation has been wildly accelerated by the accretion of material from a companion star (which, in Calvera's case, would have been fully devoured or dispersed long ago). If this hypothesis were true, Calvera would be a lot closer to Earth: between 250 and 1,000 light-years away, making it one of the nearest neutron stars. But when the investigators pointed a radio telescope at Calvera, they did not detect the ultrafast pulses expected of a millisecond pulsar. "That definitely deepened the mystery," Fox says. The researchers are planning more observations of Calvera to clarify its status. And in the meantime, they are beginning to study 10 other isolated x-ray sources that may turn out to be equally baffling.



**ON ITS OWN:** Artist's rendition of an isolated neutron star shows the magnetic field lines surrounding the ultradense stellar remnant.

er observations with space- and ground-based telescopes revealed an object whose spectrum was roughly similar to those of the Magnificent Seven. But the new object was different enough from the other INS sources that the researchers eventually named it Calvera, after the villain who fought the seven hired gunmen in the film. Calvera is located at an unusually high galactic latitude; from Earth's perspective, the neutron star is about 30 degrees above

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