Millisecond pulsars deepen a cosmic mystery

Sending out bursts of radio waves up to 600 times a second, millisecond pulsars have intrigued astronomers since a discovery four years ago that some reside at the heart of dense amalgams of Milky Way stars. These cosmic lighthouses offer clues to the evolution of globular clusters, ancient star groupings that rank among the oldest objects of our galaxy.

Until recently, scientists had identified only 13 millisecond pulsars distributed among 12 globular clusters. In the July 18 NATURE, an international team of astronomers has announced it discovered 10 more of these rapidly rotating compact stars in a single cluster – nearly doubling the known number of these enigmatic objects.

While shedding light on the nature of globular clusters, the finding deepens the mystery of how millisecond pulsars formed, notes Richard N. Manchester of the Australia Telescope National Facility in Epping, New South Wales.

He and his co-workers used the Parkes (Australia) radiotelescope to search for pulsars in the globular cluster known as 47 Tucanae, completing a total of 80 observations from 1989 through February of this year. The team had previously found a single millisecond pulsar in the cluster and used characteristics of its radio signal to identify the 10 new ones.

Manchester notes that 47 Tucanae's dense core made it a likely place to find millisecond pulsars, which are believed to be formed by gravitational capture of a neutron star by a neighboring star. The cluster's proximity to Earth – about 13,000 light-years away, or half the distance of most globular clusters – enabled the researchers to more easily detect weak pulsars. The astronomers also took advantage of the fluctuating electron density between 47 Tucanae and Earth – which occasionally amplified radio signals – to listen in on signals that otherwise would have gone undetected.

The evolution of millisecond pulsars reads like a cosmic thriller. These pulsars begin life as rapidly rotating, radio-emitting neutron stars. But within about 10 million years – a relatively short time, astronomically speaking – most will have wound down, exhausted by the braking action of their magnetic fields (SN: 4/6/91, p.218), and ceased radio emissions.

Some pulsars residing within the star-packed confines of a globular cluster, however, get a new lease on life. Gravitationally pairing off with a neighboring, lower-mass star in the cluster's core, the dying pulsar steals mass from its new companion and spins back up. Many researchers believe the orbiting duo becomes an object called a low-mass X-ray binary. This system sustains the pulsar – and revs up its spin. This "born-again" pulsar now rotates with a period measured in milliseconds.

Manchester says the relatively large number of millisecond pulsars in 47 Tucanae suggests that the ancient cluster began with a star population more massive than previously thought. His team's continuing survey has found a few additional "intriguing suspects" that may also be pulsars, he told SCIENCE NEWS. Indeed, writes Charles Bailyn in a commentary accompanying the NATURE article, "As the cluster continues to be observed ... we can confidently expect many more pulsars to be discovered in it."

Manchester notes that finding 10 pulsars in one cluster has another important implication for 47 Tucanae: Neutron stars may represent a significant amount of its "dark matter" – mass that does not emit photons but does exert a gravitational influence.

The newly discovered pulsars add further mystery to an old puzzle. While many astronomers believe that low-mass X-ray binaries give birth to millisecond pulsars, researchers have found far fewer of these binaries than pulsars in clusters. For example, astronomers have found only one X-ray binary in 47 Tucanae, compared with 11 pulsars. Manchester suggests that the imbalance could be explained if the X-ray binaries have an even shorter lifespan – perhaps one-hundredth that of the millisecond pulsars.

Changes in the pulsars' periodic emission of radio waves – alterations largely due to gravitational interactions with nearby stars – may also provide researchers with new clues to the composition of the cluster's core, says Bailyn, an astrophysicist at Yale University in New Haven, Conn.

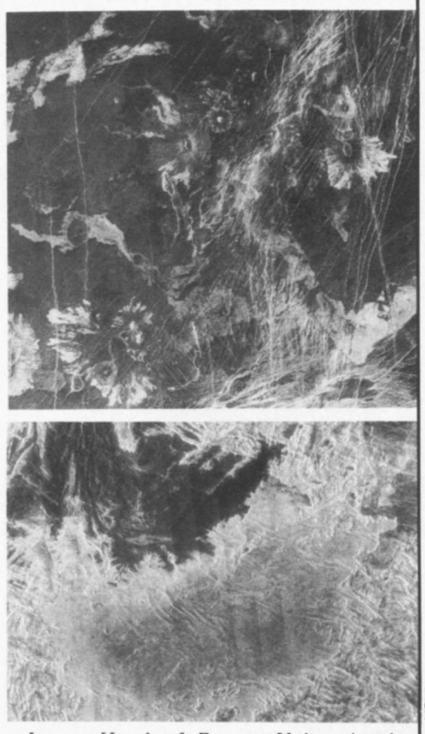
The apparent abundance of pulsars in 47 Tucanae also bolsters a new theory about why globular clusters contain little gas – despite the sizable amount generated during stellar activity in these dense objects. A separate report in the same issue of NATURE by David N. Spergel of Princeton (N.J.) University proposes that strong winds produced by millisecond pulsars continually sweep gas out of the clusters. Just a few dozen pulsars would suffice to keep a cluster gas-free, he notes.

– R. Cowen

New views of Venus' unusual volcanism

New radar images of Venus, obtained by the Magellan spacecraft, add details about a planet dominated by volcanoes and rivers of lava. While some of the features shown here resemble geologic activity on Earth, most appear unique.

The far greater atmospheric pressure on Venus can prevent volcanic gases from escaping lava and shooting into the atmosphere as a giant cloud. For example, a large lava flow deposited on the rugged uplands of Venus' Ovda region (bottom photo) may represent a volcanic eruption so powerful that on Earth it would have issued a gas cloud rivaling the one spewed out during the recent eruption of Mt. Pinatubo (SN: 7/6/91, p.7). Instead, the Venusian outburst created a thick, viscous surface flow some 140 kilometers wide and 100 kilometers long, with finger-like lobes of lava extending in all directions from the central mass of the eruption. Researchers estimate the lava's thickness at about 200 meters. Though unusually thick for Venus, it resembles the depth of silica-rich lavas on Earth.



NASA

Each of the flower patterns dotting Venus' Atla region (top photo) reveals evidence of an individual volcano, notes James Head of Brown University in Providence, R.I. This Magellan image, depicting an area about 350 kilometers across, shows petal-shaped lava flows emanating from circular pits or linear fissures in several areas. Surface fractures and valleys crisscrossing the volcanic deposits may have formed after the eruptions.

Lacking Earth's efficient weathering processes, such as wind and rain – which erase new surface features – Venus suffers little erosion. Thus it preserves evidence of volcanic activity for long periods, allowing scientists to now begin investigating how the planet's volcanism may have changed over time, explains Head, a geologist on the Magellan scientific team.