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Elegant spiral arms betray existence of massive binary stars within bright star cluster near galactic core

FOR IMMEDIATE RELEASE

Kamuela, Hawaii – The five red stars that make up the Quintuplet Cluster – one of the most massive clusters in the Milky Way Galaxy – may all be dusty pinwheels, a strange but beautiful type of nebula only recently recognized.

Two of the five have been imaged in the near infrared with the Keck I telescope on Mauna Kea in Hawaii, and display the pinwheel shape characteristic of two stars rotating around one another and spewing out dust in a spiral arc in the same way a rotating lawn sprinkler creates a water spiral.

Dubbed colliding wind binary "pinwheel" nebulae, they could be common among the most massive binary stars approaching the ends of their lives. Massive stars – in this case, between 10 and 20 times the mass of our sun -- live fast and die young, according to astrophysicist Peter Tuthill of the University of Sydney, Australia. Tuthill led the group that published images in the most recent issue of *Science* of the two confirmed pinwheels in the Quintuplet Cluster.

Perhaps only a few million years old, these stars have essentially blown off all the hydrogen in their envelopes and are nude helium stars fusing helium into heavier elements in the core. Called Wolf-Rayet stars, they have strong stellar winds that, in a binary system of two such massive stars, collide and generate copious dust. The cool dust nursery at the collision front between the stellar winds is carried around with the natural orbital motion of the two stars, trailing dust as it turns. In the case of one of these stars, the spiral covers 300 astronomical units, or 300 times the radius of Earth's orbit.

"Wolf-Rayet stars are very compact and hot, driving off intense stellar winds," he said. "But because they are shrouded in dust, you could never observe whether there is a binary at the core. When you see this elegant spiral tail of gas and dust, however, it tells you immediately that you're looking at a colliding wind binary."

The Quintuplet Cluster is less than 100 light years from the core of the Milky Way Galaxy, located 25,000 light years from Earth in the constellation Sagittarius. Estimated to be about 4 million years old, the cluster's massive young stars shine brighter than any cluster in the galaxy. Though obscured by dust until 1990, infrared imaging has since revealed the five brightest stars to be 10,000 to 100,000 times brighter then the sun. They will probably soon explode as supernovae or hypernovae.

With a mass greater than 10,000 suns, the Quintuplet Cluster is 10 times larger than typical young star clusters scattered throughout the Milky Way and is destined to be ripped apart in just a few million years by gravitational tidal forces in the galaxy's core. It also is the home of the brightest star seen in the Galaxy, called the Pistol star.

Images of the cluster taken in 1997 by the Hubble Space Telescope's near-infrared camera, NICMOS, showed the five brightest stars for which the cluster is named as bright red dusty points of light, according to Tuthill. Using speckle interferometry with the near-infrared camera on Keck I in 1998 and 1999, he and his colleagues obtained five times greater resolution than Hubble, enabling them to see the actual spiral dust cloud in two of the five stars.

"With five times greater resolution on the Keck Telescope, we could really focus in on the core of the star and drill deep down into the physics of these massive stars, finally answering the mystery of what these enigmatic cocoon stars are," he said.

Tuthill and colleagues William C. Danchi and John Monnier, all then at the University of California, Berkeley's Space Sciences Laboratory, reported the first such spiral nebula in 1999 associated with the binary star system WR 104. Danchi, now at the NASA Goddard Space Flight Center in Houston, and Monnier, now an assistant professor of astronomy at the University of Michigan, Ann Arbor, are coauthors on the current Science paper, along with Angelle Tanner of the Jet Propulsion Laboratory in Pasadena, Donald Figer of the Rochester Institute of Technology, and Andrea Ghez of the University of California, Los Angeles.

Massive stars like those in the Quintuplet Cluster are important because, though they typically make up only a few percent of the stars in a galaxy – that is, a few thousand stars our of billions – they outshine all the other stars put together. They also exert a strong influence on other stars because of their intense stellar winds, which produce shock waves that compact dust and gas into new star-forming regions, or disrupt such regions to stall star formation.

"These massive stars shove everything around with their strong winds, exerting a big influence on the evolution of the galaxy as a whole," Tuthill said.

They also seed the galaxy with heavy elements when they explode. Binary systems like those in the Quintuplet Cluster are destined for three supernova explosions: each star separately, possibly producing a brilliant "long" gamma-ray burst and leaving behind a neutron star or black hole; and a third time when the two compact objects spiral into one another and merge in an explosion thought now to generate "short" gamma ray bursts.

From their observations, Tuthill calculated that one of the binary star pairs is separated by a couple of astronomical units (AU), where an AU is the average distance between the Earth and Sun: 93 million miles. They orbit one another every 750-950 days.

While they were unable to see structure within the dust enshrouding the three other bright stars of the cluster, all show similar characteristics to the two pinwheel nebulae. Tuthill suspects that they too are colliding wind binaries, either too tightly wound to resolve or tipped at an angle such that the spirals are obscured.

He noted that the discovery of two and perhaps five massive binaries in a young, bright cluster suggests that many of the very luminous stars in our galaxy – most of which are surrounded by dust -- harbor massive binaries, not single stars. This would have implications for our understanding of supernova explosions and the brightness and evolution of stars, he said. Interestingly, ripples have been seen in the light curve from one supernova , possibly caused by the supernova shockwave encountering the spiral arms of a colliding-wing binary as it expanded outward.

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For images of the two newly discovered spiral nebulae, link to http://www.keckobservatory.org/article.php?id=90 or http://www.physics.usyd.edu.au/~gekko/quintuplet.html.

Credit: Don Figer (STScI) and NASA