Mira stars are wonderfully complex

Newly discovered gas layers around Mira stars reveal the stars' true sizes.

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Mira stars are only half as large as previously thought, according to a new study. Named for Mira, or Omicron (o) Ceti, this class of stars contains variable red giants with periods ranging 80 to 1,000 days and apparent brightnesses fluctuating by as much as a factor of ten with each cycle. Despite their immense sizes, Mira stars are mere pinpoints of light to the unaided eye, and even the largest telescopes cannot resolve their surfaces. Using interferometry, however, a technique that combines light from multiple telescopes, an international team of astronomers revealed the close environment of Mira stars — and their actual sizes.

The team, led by Guy Perrin of the Paris Observatory/LESIA and Stephen Ridgway of the National Optical Astronomy Observatory in Tucson, Arizona, observed five Mira stars — Chi (χ) Cygni, U Orionis, T Cephei, R Leonis, and Mira itself — in near-infrared wavelengths. These stars are among the brightest — and, in apparent size, largest — Mira variables visible in the Northern Hemisphere.

Miras have long been known as molecule and dust "factories." Their relatively cool temperatures allow molecules like water and oxides of carbon, silicon, and titanium to form. Owing to their pulsation and overall large diameters, Miras lose mass at a billion times the rate of Sun-like stars, surrounding themselves with dense, complex shells of matter. When Miras finally bare their white-hot cores, these circumstellar envelopes light up as proto-planetary nebulae. Mira stars are interesting to astronomers because they show the fate of our own Sun in 5 billion years.

The astronomers used the Infrared-Optical Telescope Array (IOTA) of the Smithsonian Astrophysical Observatory in Arizona for their work. IOTA has two arms connected at 90° and three collectors, which can be positioned at different stations along the arms. To collect data at different wavelengths, the collectors were spaced 33-125 feet (10-38 meters) apart.

Perrin's team found systematically larger sizes for Miras when viewing the stars at infrared wavelengths produced by water vapor and carbon monoxide. To explain these observations, the astronomers propose that Miras consist of a star surrounded by a thin, nearly transparent, molecular shell that extends at least one stellar radius. An outer layer of this shell dominates its transparency at infrared wavelengths, creating the illusion that Miras are twice their actual size.

While Perrin's group openly admits this model is an "extreme simplification," they argue that it naturally reconciles why these stars appear different sizes in different wavelengths. It also confirms earlier suspicions, based on understanding of the physics of pulsation, that Miras have smaller diameters. Their empirical approach "must be considered as a serious and even preferred option," they write, "until dynamical models come into better agreement with observations." The journal *Astronomy & Astrophysics* will publish the team's results.