Large Survey Identifies Young Binaries To Test Models Of Star Formation

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A classic poprtrait of the nebulous region surrounding the star Rho Ophiuchi. Credit: Loke Tan, Santa Barbara Instrument Group

Results from the largest survey of its kind conducted at the W. M. Keck Observatory in Hawaii provide data to test theories describing how small, relatively cool, but numerous "M-class" stars are born and change over time. The results will help scientists understand how the most common type of stars in the universe form in molecular clouds, and how and at what rate they develop.

Dr. Lisa Prato of Lowell Observatory used the Keck II telescope on Mauna Kea to study a sample of 33 of the youngest observable cool stars. All targets were located in the star-forming region of Ophiuchus. Dr. Prato searched for extremely close stellar pairs because they can be used to determine the relative mass of each stellar component. The observations took three years to complete and represent the largest homogenous survey of low-mass, young stars of its kind on record. Dr. Prato's work will provide input data to help calibrate models for the early stages of star formation and evolution.

"The big product I get is a set of mass ratios, which go a long way towards testing evolutionary models," said Dr. Prato. "Given a mass ratio and a reasonable estimate of a primary star's mass I can take a star of a certain spectral type at a certain age and mass, and plot it on the theoretical diagrams. If the secondary star doesn't line up with the model, then something is wrong with the model."

Four of the 33 targets, or 12 percent of the objects, were found to be very close pairs with separations similar to - or smaller than - the Earth-Sun distance. Only a highly sensitive instrument like NIRSPEC, paired with a large-aperture telescope like Keck II, is capable of measuring the small motions induced by the binary companions to these faint stars. "Dr. Prato uses the same technique for finding binary stars as the Planet Hunters use to find planets, only she works with a different wavelength of light and uses a different instrument," said Dr. Taft Armandroff, director of the W. M. Keck Observatory. "So this is a classic example of the type of result for which large telescopes like the Kecks were built."

Dr. Prato's findings are consistent with those found in previous surveys of older and more massive stars. Thus, Dr. Prato's discoveries suggest there is no relative scarcity of the closest young, low-mass double star systems in the Milky Way Galaxy, particularly in the Ophiuchus star-forming region. The results of Dr. Prato's survey further support a

scenario for continuous star formation in Ophiuchus.
In addition, Dr. Prato serendipitously discovered five previously unknown wider double-star pairs with separations of 14 to 140 times the Earth-Sun distance. One of these is a hierarchical four-star system. There is some evidence on this basis that stars may prefer to form in multiple, hierarchal systems. With more observations in this region, Dr. Prato suspects that yet more of the closest stellar binaries and triplets might be discovered.

"I don't think binaries will end up being the most common thing we see 50 years from now," added Dr. Prato. "I think it will be triples or something, but we won't know for sure until we take many more observations."

Evolutionary models for stars similar to or a few times the mass of the Sun are fairly well understood and are supported by accurate observations. However, for stars much smaller than the Sun, the process is not as well understood. The common theory is that stars form from dense and dusty molecular clouds, composed mostly of hydrogen gas. Gravitational instability in the region causes a cloud core to collapse until the density and pressure at the core becomes so great nuclear fusion begins.

The size and temperature of the resulting star depend on the initial cloud core conditions. The extent to which these various physical forces affect the outcome of how a small, young star evolves is still under investigation. Some of the most useful evidence comes from the youngest double-star systems that can be observed with a telescope. Because the nearest star-forming regions where these objects are located are about 450 light years away, and because these stars are small and cool, the objects are intrinsically very faint. None are visible to the unaided eye, and it is essential to use a large telescope such as Keck II for such a study. The Keck Observatory's NIRSPEC instrument is one of

only a few instruments in the world able to accurately measure the mass ratios of the newly discovered close binary pairs.

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Source: W. M. Keck Observatory