How Do Multiple-Star Systems Form?

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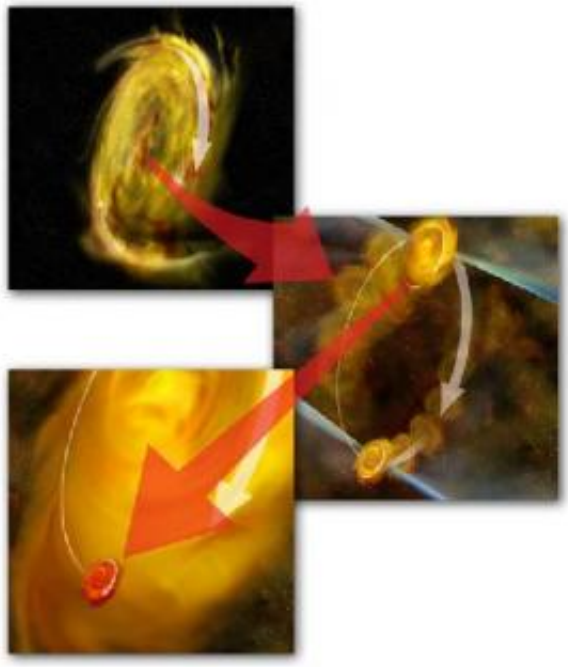

ARTIST'S CONCEPTION of proposed formation process for the multiple-star system L1551 IRS5, as revealed by observations with the Very Large Array (VLA) radio telescope. Top panel: large disk-like cloud of gas and dust rotates. Middle panel: two smaller disks of gas and dust fragment from the large disk and begin to condense into protostars, each having its own surrounding disk and shooting "jets" of material outward from the poles of its disk. Bottom panel: A third, smaller disk and protostar joins the sytem, either through the same fragmentation process or by being captured gravitationally by the larger protostars. CREDIT: Bill Saxton, NRAO/AUI/NSF

Astronomers have used the National Science Foundation's Very Large

Array (VLA) radio telescope to image a young, multiple-star system with unprecedented detail, yielding important clues about how such systems are formed. Most Sun-sized or larger stars in the Universe are not single, like our Sun, but are members of multiple-star systems. Astronomers have been divided on how such systems can form, producing competing theoretical models for this process.

The new VLA study produced a "smoking gun" supporting one of the competing models, said Jeremy Lim, of the Institute of Astronomy & Astrophysics, Academia Sinica, in Taipei, Taiwan, whose study, done with Shigehisa Takakuwa of the National Astronomical Observatory of Japan, is published in the December 10 issue of the *Astrophysical Journal*.

Ironically, their discovery of a third, previously-unknown, young star in the system may support a second theoretical model. "There may be more than one way to make a multiple-star system," Lim explained.

The astronomers observed an object called L1551 IRS5, young, still-forming protostars enshrouded in a cloud of gas and dust, some 450 light-years from Earth in the direction of the constellation Taurus. Invisible to optical telescopes because of the gas and dust, this object was discovered in 1976 by astronomers using infrared telescopes. A VLA study in 1998 showed two young stars orbiting each other, each surrounded by a disk of dust that may, in time, congeal into a system of planets.

Lim and Takakuwa re-examined the system, using improved technical capabilities that greatly boosted the quality of their images. "In the earlier VLA study, only half of the VLA's 27 antennas had receivers that could collect the radio waves, at a frequency of 43 GigaHertz (GHz), coming from the dusty disks. When we re-observed this system, all the antennas could provide data for us. In addition, we improved the level of detail by using the Pie Town, NM, antenna of the Very Long Baseline

Array, as part of an expanded system," Lim said. The implementation and improvement of the 43 GHz receiving system was a collaborative program among the German Max Planck Institute, the Mexican National Autonomous University, and the U.S. National Radio Astronomy Observatory.

Two popular theoretical models for the formation of multiple-star systems are, first, that the two protostars and their surrounding dusty disks fragment from a larger parent disk, and, second, that the protostars form independently and then one captures the other into a mutual orbit.

"Our new study shows that the disks of the two main protostars are aligned with each other, and also are aligned with the larger, surrounding disk. In addition, their orbital motion resembles the rotation of the larger disk. This is a 'smoking gun' supporting the fragmentation model," Lim said.

However, the new study also revealed a third young star with a dust disk. "The disk of this one is misaligned with those of the other two, so it may be the result of either fragmentation or capture," Takakuwa said.

The misalignment of the third disk could have come through gravitational interactions with the other two, larger, protostars, the scientists said. They plan further observations to try to resolve the question.

"We have a very firm indication that two of these protostars and their dust disks formed from the same, larger disk-like cloud, then broke out from it in a fragmentation process. That strongly supports one theoretical model for how multiple-star systems are formed. The misalignment of the third protostar and its disk leaves open the possibility that it could have formed elsewhere and been captured, and we'll continue to work on reconstructing the history of this fascinating system," Lim summarized.

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Source: NRAO