Infrared Image of Circumstellar Disk Illuminates Massive Star Formation Process

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HD200775 and its nebula. . (This image was created from archive data of the Digitized Sky Survey and 2 Micron All-Sky Survey.) The bright star at the center is HD200775, which illuminates the surrounding nebula. The upper and lower part of HD200775 is the reflection nebula NGC7023. The hourglass-shaped nebula extending in the east-west direction (east is left) encircles a cavity formed by past outflow activity. Okamoto et al. zoomed in and imaged an area around HD200775.

(PhysOrg.com) -- A team of astronomers from Ibaraki University, Japan Aerospace Exploration Agency, Kanagawa University, University of Tokyo, Academica Sinica, and National Astronomical Observatory of

Japan have used the Subaru Telescope's Cooled Mid-Infrared Camera and Spectrometer (COMICS) to capture the first direct, well-resolved infrared images of a circumstellar disk around a young massive star -- HD200775. Their findings contribute to understanding the role of circumstellar disks in massive star formation in particular and to the birth of stars in general.

Massive stars are those with masses eight times greater than that of the Sun, and they are the most prominent objects in distant galaxies. They illuminate a large area around them and form a nebula of ionized gas as they develop into mature stars. At the end of their lives, they explode as supernovae and scatter many kinds of heavy elements like iron into interstellar space.

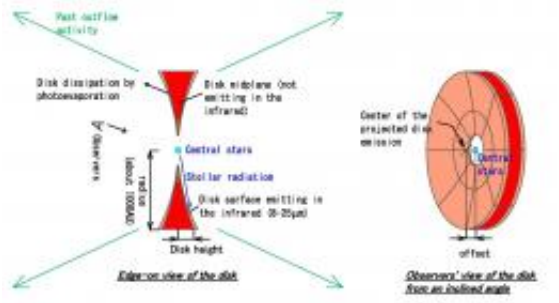
Scientists understand relatively well how stars with masses similar to our Sun's are born: their cloudy cocoon of natal gas contracts and forms circumstellar disks, which provide the mass that feeds their central stars. These circumstellar disks are referred to as protoplanetary disks since they are likely to become the birthplaces of planets. Images of disks around low mass stars are relatively common, and are helpful for detailed studies of the properties of disks and how they relate to planet formation.

However, the formation of massive stars is less well understood, and there have been no direct images of circumstellar disks around massive stars in either the infrared or visible wavelengths. Scientists have proposed two models to explain the creation of massive stars. In the disk accretion scenario massive stars develop much as low mass stars do; their disks provide the mass to feed them as they grow. In the merging scenario, massive stars are formed when less massive stars merge with each other.

Several observations made in the 2000s indicated that some massive

stars were formed by accretion; their circumstellar disks fed them the mass to increase in size. Observations with the Subaru Telescope, fitted with its Coronagraphic Imager with Adaptive Optics (CIAO), also yielded these results in 2005. In August 2006, June 2007, and July 2008, the current team used the Subaru Telescope, fitted with COMICS, to make infrared observations of the young massive star HD200775 in the constellation Cepheus. What would its circumstellar disk reveal about how this massive star was born?

HD200775 is located 1400 light-years from Earth and is actually a close binary system that contains at least one massive star that is about 10 times the mass of the Sun. A large cavity of molecular gas surrounds the star and extends east to west from the central stars. Molecular gas is dense within the cavity wall, and HD200775 illuminates the gas closest to the star, forming the reflection nebula NGC7023. The binary orbit extends in the north-south direction, indicating that the binary is almost seen in its orbital plane.



On the left side is the disk in an edge-on configuration. The disk has a flared shape; its height increases rapidly as the radius increases. The central star heats and illuminates the disk well into the outer region so that this area emits in the infrared. On the right side is the disk seen from an inclined angle. The center of the elliptical disk emission is slightly displaced from the stellar position. The disk seems to evaporate from the surface and rapidly dissipate.

The infrared images captured by COMICS revealed an elliptical emission with the same direction as the binary orbit. The research team found that the emission arises from a circumbinary disk (a disk that surrounds both stars of the binary system) around HD200775, the orbital plane of which is similar to that of the binary. The direction is consistent with the fact that an outflow generally occurs in a direction perpendicular to a disk. The images taken this time are significant because they are the first clear and direct infrared images of a disk around a massive star.

The team examined the disk images in detail and found that the center of the disk emission shifted from the central stars. This indicates that the disk is not flat but flared; the disk height increases as the disk radius increases. Such a flared disk is very similar to that found for star HD97048, which is twice as massive as the Sun.

The team also found that strong ultraviolet irradiation from the central star seems to evaporate the gas of the HD200775 disk, leading them to believe that the star itself quickly dissipates the disk that surrounds the binary stars. This is one reason that it is difficult to find disks around massive stars. Though massive stars may be created through an accretion process similar to that of lower mass stars, the fate of the circumstellar disk is different.

In summary, this research shows that a massive star up to 10 solar masses has a circumstellar disk similar to stars like Earth's Sun. The team concluded that the star HD200775 probably formed from the accretion of mass from its disk. Nevertheless, the results also indicate that disk evolution depends on the masses of the central stars. In the future, it will be interesting to tackle more challenging questions. Do the disks of other massive stars form through similar processes? Do planetary systems form around massive stars? Subaru Telescope will be a powerful ally in studying these exciting issues.

These research results are published in the November 20, 2009 issue of the *Astrophysical Journal*.

Provided by Subaru Telescope