A Lightweight Disk Around a Lightweight Star May Harbor Earth−like Planet (Forwarded)

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A Lightweight Disk Around a Lightweight Star May Harbor Earth−like Planet

A team of Japanese astronomers resolved a circumstellar disk around the young lightweight star FN Tau. The diminutive star is located in a star−forming region toward the Constellation Taurus at a distance 460 light years from Earth. This research group (Note 1) used the Coronagraphic Imager with Adaptive Optics (CIAO) at the Subaru Telescope to directly image FN Tau and the lightweight disk of planet−forming material surrounding it (Figure 1). This star is merely 100 thousand years old and weighs only one tenth of the Sun.

For background, a circumstellar disk is a mixture of gas and dust around a young newly formed star. The disk accompanies almost most, if not all, sun−like star formation processes, and planets commonly form in this disk. The disk can also be referred to as a protoplanetary disk (referred to simply as a "disk" in the following text) because the solid particles inside the disk collide and stick together and grow into planetesimals, which then crash into each other eventually accumulating enough mass to be stabilized as planets. In response to this scenario, the study of youthful stars and their surrounding structures provide details into the formation of planetary systems, and the search for planets outside our solar system motivates much of modern astronomy. Although hundreds have been found through indirect methods, being the first to directly image an extrasolar planet is one of the primary goals of Subaru. The findings at FN Tau show that Subaru is on the right path toward planet discovery.

Observation of protoplanetary disks is not simple because they are small and fainter than their central stars. To date, there are only a few examples that were resolved to show the structures of disks, and only two of them are for Sun−like single stars. Thus far, the Subaru Telescope has pointed toward more massive disks around stars heavier than the Sun (Note 2). The FN Tau researchers pointed the telescope toward this least massive star trying to detect lightweight disks. The previous record of the direct

imaging of lowest mass disks was around star TW Hya, which is seven times heavier than the FN Tau disk. The small size in this study is a big jump in knowledge about planet formation around lowest mass stars.

The FN Tau study found a thick, compact, and roughly circular protoplanetary disk, meaning astronomers were observing it nearly face−on. Its radius is 260 times the Earth−Sun distance, similar to other disks observed previously. The disk is rather featureless, and does not have any anomalies or asymmetries, such as rings, spirals, or arms. The mass of the disk was estimated to be 6% of the central FN Tau star, and by far the least massive one directly detected. In result, the current finding is the combination of the most lightweight protoplanetary disk around the least massive star. An artistic rendering of the FN Tau system is shown in Figure 2.

One of the questions to come out during the study was what kind of planets can be formed from the disk around FN Tau? To date, astronomers worldwide have found 270 extrasolar planets using the indirect detection method, and all are primarily Jupiter−like giant planets; the least massive exoplanet is still 5 times heavier than Earth. Because it surrounds a smaller star, the disk about FN Tau was believed to more likely contain Earth−like planets. The best−fit model used during this study shows that the lightweight disk around FN Tau could only produce Earth−like planets. The planetary system formation theory also predicted that the disk is able to form planets lighter than the Earth within 30 AU, the distance where we find planets in our Solar System (Note 3). The lack of heavier objects, such as a Jupiter−size planet, in the FN Tau disk system is consistent with the astronomers' theoretical expectation.

For the future, the newly commissioned instrument HiCIAO at Subaru will boost the approach of this team (see December 26, 2007 News Release). The high dynamic range instrument also will have powerful reinforcement with Subaru's new generation AO system with 188 elements and laser guide star (see November 20, 2006 News Release). The astronomers are hoping to resolve the detailed structure of disks and analyze the size and composition of the dust within. The team will narrow their targets before observations start at ALMA (Atacama Large Millimeter Array) or the next generation large telescopes.

This discovery is reported in the Astrophysical Journal Letters in its January 20, 2008 issue, Volume 673, page L67.

NOTES

Note 1: Team members are in the Graduate University of the Advanced Studies (SOKENDAI), National Astronomical Observatory, ISAS/JAXA, Nagoya University, Kobe University, and Ibaraki University. This research is supported by Grants−In−Aid for Scientific Research on Priority Areas, "Development of Extra−Solar Planetary Science", from the Ministry of Education, Culture, Sports, Science and Technology (16077101, 16077204), and by JSPS (16340061).

Note 2: More massive protostellar disks show more diverse structures, as revealed by CIAO/Subaru, such as the spiral structure or a pair of arches.

Spiral pattern in the protostellar disk
http://www.subarutelescope.org/Pressrelease/2004/04/18/index.html

Pair of arches
http://www.subarutelescope.org/Pressrelease/2006/06/27/index.html

Note 3: Astronomical unit (= 1 AU) is the mean distance between the Sun and the Earth, 150 million kilometers, or approximately 95 million miles.

Note 4: About CIAO at Subaru Telescope
http://www.subarutelescope.org/Introduction/instrument/CIAO.html

About AO (its first generation version −− 36 elements −− at Subaru Telescope)
http://www.subarutelescope.org/Introduction/instrument/AO.html

IMAGE CAPTIONS:

[Figure1:
http://subarutelescope.org/Pressrelease/2008/02/08/fig01.jpg (176KB)]
FN Tau captured by CIAO instrument mounted on Subaru Telescope. This infrared image taken at 1.6 micron shows an almost face−on circular disk structure. The light from the central star FN Tau itself is blocked by the coronagraph mask. Somewhat symmetrical darker areas are the blocking by the secondary mirror support.

[Figure 2:
http://subarutelescope.org/Pressrelease/2008/02/08/fig02.jpg (90KB)]
Illustration of the protoplanetary disk around FN Tau. Because central star has only one tenth of the mass of the Sun, its gravity is small and the disk becomes thicker with increasing distance from the central star. Resultantly, the scattering of light from the star is more efficient than that by a flat disk and the disk appears brighter than expected.

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