Duo of big telescopes probes the depths of binary star formation

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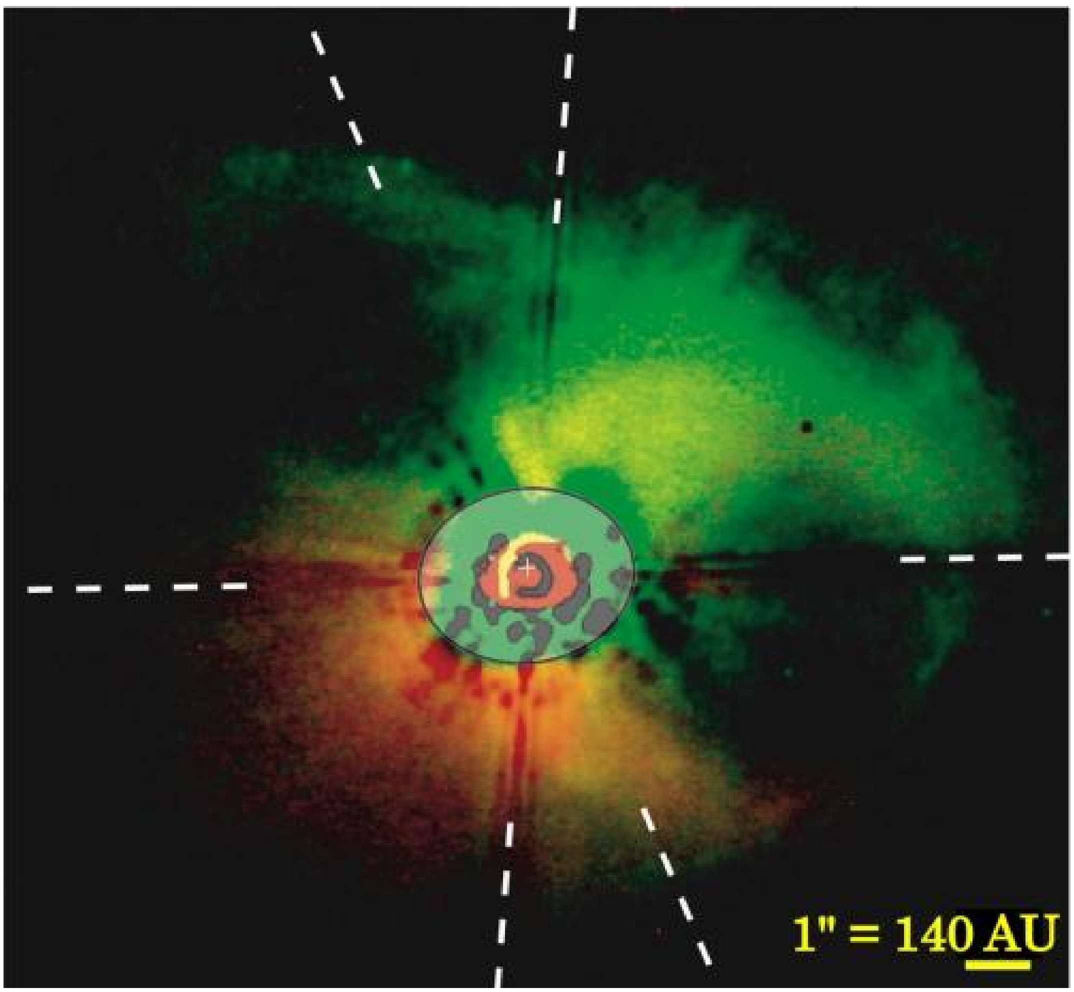

Figure 1: A composite image toward Taurus FS A binary system. The green color shows the intensity of visible light, based on optical data from the Hubble Space Telescope. The red color displays near-infrared data from the Subaru Telescope. The ellipse marks an artifact from data processing of the central bright star. The dashed lines denote the directions of the support of the secondary mirror of the telescope. The field of view is 16.5" x 17.5". North is

up, and east is to the left.

A team of researchers from four Japanese universities (Kobe, Saitama, Osaka, and Tokyo) has been able to delineate the intricate structure of the circumbinary disk that surrounds a young binary star system from the observation with the Subaru Telescope and the Hubble Space Telescope. By using different wavelengths to examine the system's internal structure, they succeeded in demonstrating a distinct color difference between its northern and southern portions. The researchers are now prepared to apply their approach of combining optical and near-infrared observations to other regions of binary formation.

Previous observations have demonstrated that protoplanetary disks, composed of a ring of dense gas surrounding a star like our Sun, not only accompany many infant stars but also are sites that generate planetary systems such as the one to which our Earth belongs. Therefore, these disks provide important information about the formation of stars and planets.

Past observations have focused on the protoplanetary disks of single stars. However, stellar research reveals that the majority of stars are members of binary or multiple star systems rather than ones composed of a single star. The research team addressed the issue of limited research on binary systems by pointing the Subaru Telescope toward the FS star system in the constellation Taurus. The separation between the primary (A) and companion (B) stars is 20 arc seconds (2800 AU; astronomical unit, the distance between the Sun and the Earth) and the FS A star itself is also a binary system with only 0.2 arc seconds (30 AU) of separation between its stars. The research team succeeded in detecting a circumbinary disk by using the Subaru Telescope's near-infrared camera CIAO (Coronagraphic Imager with Adaptive Optics), which blocks out the bright light of the central star. The disk's size of 630 AU is equivalent to the aphelion (the furthest point from the Sun in its orbit) of Sedona, one of the trans-Neptunian objects.

The team then compared its near-infrared image with the optical image taken by the Advanced Camera System (ACS) aboard the Hubble Space Telescope (HST). The area north of the FS A binary is brighter in the visible light (optical), while that south of the binary stands out in the near-infrared. In other words, the north is blue, and the south is red. The protoplanetary disk reflects the visible or the infrared light from the central star, but it does not emit light by itself. The highly distinct color contrast between the northern and southern portions of FS A's protoplanetary disk is a very unique characteristic of the system.

The question becomes why the color is different in these regions around the binary. Part of the answer relates to the degree of the polarization dispersed from the surface of the disk. Regardless of whether the light is visible or near-infrared, it displays the properties of a wave as well as a particle, and its reflection shows polarization. The degree and the direction of the polarization provide information about the object that reflects the light. This is why measurement of the polarization is important for understanding the structure of the protoplanetary disk. The observation with the Hubble Space Telescope included information on polarization, and figure 2 shows the distribution of the polarized light. The majority of the disk shows a typical concentric pattern around the central star. Other protoplanetary disks show similar patterns.

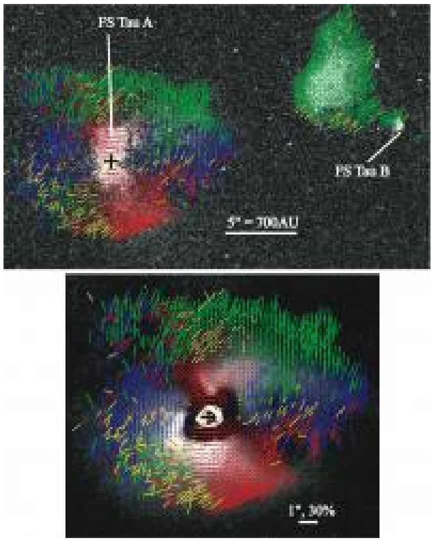

Figure 2: The polarization distribution in visible light, overlaid on the visible image (top) and near-infrared image (bottom). The color-coding refers to the offset from the expected centro-symmetric pattern around FS A star and FS B star. The blue and red colors show the circular pattern around FS A while the green encircles FS B. The area toward the southeast of FS A is bright in the near infrared, and the offset, denoted by the yellow color, is larger. The fields of view are 19" x 31" (top) and 14" x 17" (bottom), respectively. North is up and east is to the left.

In addition to its circular pattern, the outer region to the north reflects the light from the FS B star, which is much further away from the FS A system. The research team interpreted this feature as an effect of abundant interstellar material in front of the FS A circumbinary disk and the influence of the FS B. However, the polarization data show that the inner region to the north is part of the protobinary disk surrounding the FS A binary. The mystery of color difference remains.

In sum, the research team established that there is a distinct color difference between the areas to the north and south of the circumbinary disk of the FS A star. They want to continue observations of protoplanetary disks so that they can identify their common characteristics and chronicle their evolution. Their ultimate goal is to understand the planetary formation process in circumstellar/circumbinary disks.

More information: "High-Resolution Optical and Near-Infrared Images of the FS Tauri Circumbinary Disk", Tomonori Hioki, Yoichi Itoh, Yumiko Oasa, Misato Fukagawa, Masahiko Hayashi. June 2011 issue of the *Publications of the Astronomical Society of Japan*.

Provided by Subaru Telescope

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