NIR Polarimetric Imaging of Circumstellar Disks by Subaru/SEEDS

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SEEDS (Strategic Explorations of Exoplanets and Disks with Subaru survey) is the large survey project (2009-2014) utilizing near-infrared high-resolution imaging in the Subaru Telescope. Here, we report new results in 2013, especially in the survey of circumstellar disks. The disk-survey in SEEDS aims to investigate the relationship between planet formation and the morphology of the disk. We have published 15 papers related to circumstellar disks by 2013, and reported SR 21 [1] and RY Tau [2] in 2013.

SR 21—This is a young stellar object (a mass of $2.5 M_{\odot}$; an age of ~1 Myr) in Ophiuchus. Fig. 1(a) shows a clear inner cavity with a radius of 36 AU in the central region of the disk around SR 21 has been detected with sub-millimeter interferometry at 870 μm, possibly suggesting gravitational interaction between the disk and planet(s). These cavitated disks are referred to as `transitional disk' and are unique samples for understanding planet formation. Fig. 1(b) presents our near-infrared polarized intensity image at 1.6 μm. Surprisingly, we cannot detect the cavity structure clearly seen in the dust continuum image (fig. 1a). In general, scattering light in the NIR wavelengths can trace sub-μm-size small dust grains, while dust continuum in the sub-millimeter wavelengths can trace millimeter-size large dust grains. Therefore, observing results in figs. 1 could indicate different spatial distibutions of small and large dust grains. To understand spatial distibutions of dust grains, we conducted modeling efforts using a Monte Carlo radiative transfer code. Consequently, we hypothesize polarized intensity at NIR is dominated by an optically thin disk envelope or atmosphere component.

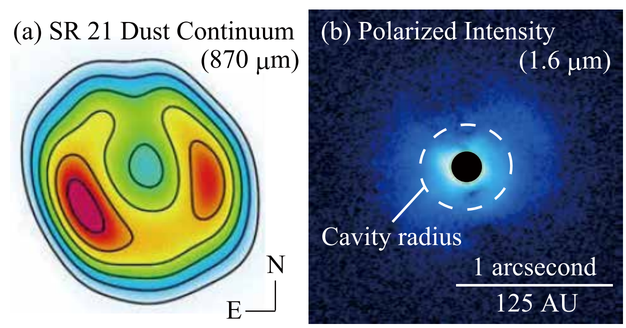

Figure 1: (a): The dust continuum image at 870 μm obtained with SMA. (b): The polarized intensity image obtained at 1.6 μm. A software mask with a diameter of 0″.2 is used due to the bright central star. A white-dashed line indicates a radius of a cavity seen in panel (a).

RY Tau—This object in Taurus is an active premain sequence star (a mass of $2 M_{\odot}$; an age of 8 Myr). RY Tau also has a cavitated disk with a radius of 15 AU. Fig. 2 is the polarized intensity image at 1.6 μm of the disk around RY Tau, showing a butterfly-like distribution. We have conducted (a) modeling efforts using a radiative transfer code to constrain the disk parameters by fitting SED; and (b) monochromatic simulations of scattered light to determine the dust and disk parameters by compareing the scattered light image. However, we cannot consistently explain the observed polarized intensity, SED, and the viewing angle inferred by millimeter interferometry. We sugget observed scattering light could be scattered in an optically thin and geometrically thick layer above the disk surface.

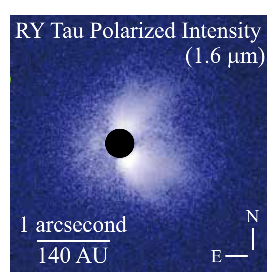

Figure 2: The polarized intensity image obtained at 1.6 μm. A software mask with a diameter of 0″.3 is used due to the bright central star, occulting the inner cavity with a radius of 15 AU (~0″.1).

References

[1] Follette, K., et al.: 2013, *ApJ*, **767**, 10.
[2] Takami, M., et al.: 2013, *ApJ*, **772**, 145.