Probing disk structure in a cavity of pre-transitional disks around Sun-like young stars

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Pre-transitional disks, which have a large cavity at the center of the disk, are considered to be in the evolutionary phase and planets including terrestrials are thought to be forming in the cavity. In the course of our previous survey using high-contrast polarized intensity (PI) imaging at H- and K-bands we have discovered a group of T Tauri stars with disks having a large cavity, suggestive of dynamical sculpting by planets.
We observed 2MASS J16042165-2130284 (hereafter J1604) and PDS 70 by sub-millimeter continuum, CO(J=3-2), and HCO+(J=4-3) emission lines by ALMA. They are all solar like low-mass pre-main sequence stars and have a large cavity of 60 –70 AU in radius, based on our H-band Subaru observation in the Strategic Explorations of Exoplanets and Disks with Subaru (SEEDS) project. As results of ALMA observations, PDS 70 shows a large hole in both dust continuum and gas observations. One of the highlights of the results for PDS70 is that the inner disk structure is connected by 2-3 bridges with the outer disk was detected by HCO+(J=4-3) emission, suggesting that dynamical interaction and mass transfer are occurring between inner and outer disk.
J1604 also shows a large cavity at the center in the sub-millimeter continuum, CO(J=3-2) and HCO+(J=4-3) emission. Previous observations showed that the cavity was completely empty but a very faint component was found in the sub-millimeter continuum and HCO+(4-3) emission. It could be an inner disk component but also it could be the emission of the central star defocused by the observed synthesized beam because the beam size is comparable with the size of the emission in the cavity. The continuum image shows a bridge structure extending from the outer ring to the center of the disk. A dip structure was detected at southwest part of the ring as other observations at optical and near infrared wavelengths. If all of the observations from optical to sub-millimeter wavelengths probe similarly distributed populations, then a persistent shadow from an inner disk cast on the outer disk would make sense. The orbital timescale in the outer disk is quite long, and the radiative cooling timescale of the dust should be quite short, so dust that orbits into the shadow should have time to cool rather substantially before coming out of the shadow again.
Further analysis and simulation to reproduce the observational data have now been undertaken and it will be reported as soon as we obtain the results.

Keywords: protoplanetary disks, planetary system formation, millimeter and submillimeter wavelength, interferometry

