Detail Structures of Dust Disk around T-Tauri star RY Tau in ALMA High-Spatial Resolution Imaging

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RY Tau is categorized as a classical T-Tauri star with a mass of 2 solar mass and an age of 2 Myr (e.g., Calvet et al. 2004). The infrared excess indicates an existence of a protoplanetary disk around RY Tau (Furlan et al. 2009), and also the star is active predicted by jet detections (e.g., St-Onge & Bastien 2008). Previously, the disk imaged by the Combined Array for Research in Millimeter-wave Astronomy (CARMA) showed a cavity structure with a radius of about 0.1 arcsec in millimeter dust continuum (Isella et al. 2010), while no structures at >0.4 arcsec were detected in near infrared by Subaru Telescope (Takami et al. 2013). We investigated the visibilities of Atacama Large Millimeter/submillimeter Array (ALMA) archival data, and predicted other fine structures in RY Tau disk. Therefore, we observed with high spatial resolution.
Our observations (Project: 2017.1.01460.S, PI: J. Hashimoto) were conducted in October 2017 in Band 6 (~230 GHz, ~1.3mm). The total integration time was 5.14 minutes. We obtained three kinds of CO isotope (^{12}CO, ^{13}CO, and C^{18}O) as well as dust continuum. The CLEANed image had a beam size of 0.087×0.036 arcsec (PA: 30.7 degree) after the measurement set was calibrated by the code provided by ALMA. The dust emission from RY Tau disk could be detected (inclination: 65.9 degrees, position angle: 22.4 degrees) and the known cavity structure at 0.1 arcsec was clearly resolved. In addition, we confirmed a spatially-resolved gap structure at 0.35 arcsec and brightness asymmetry in the inner ring that were recently reported by Long et al. 2018. We then constructed a symmetric disk model (1 cavity + 1 gap) by comparing azimuthally-averaged visibilities, to investigate details of the gap structure. The best-fitted properties derived by Markov Chain Monte Carlo method showed that the gap is narrow and deep (width: 1.2 au, depth: 0.41). Although the inclination of RY Tau system is large (about 66 degrees), we could resolve the narrow and deep gap. It indicates that the scale height of RY Tau disk is small (< ~0.27 au). Dust might be settled down by some mechanisms such as low turbulence.
It should be noted that a distance of RY Tau measured by Gaia is largely different between Data Release 1 (170 pc) and 2 (440 pc). We found that it is high possibility of 178 pc based on the velocity distribution of ^{12}CO gas taken in our observation and previous ALMA data. In this abstract, a distance of 178 pc is employed for conversion.

Keywords: Protoplanetary Disk, Disk Structures, Dust Continuum

