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High Resolution Observations of Dust Continuum Emission at 340GHz from the Low-mass T Tauri Star FN Tau

Munetake Momose[1*], Nagayoshi Ohashi[2], Tomoyuki Kudo[3], Motohide Tamura[3], Yoshimi Kitamura[4]

[1]College of Science, Ibaraki University, [2]ASIAA, Taiwan, [3]Optical and Infrared Astronomy, NAOJ, [4]Japan Aerospace Exploration Agency

Diversity of the exoplanets may stem from a variety of the properties of their precursors (i.e., protoplanetary disks). Planet formation around stars with a mass lower than Sun-like stars is especially intriguing, since these are the most abundant stars in our galaxy. FN Tau is a rare example of very low-mass T Tauri stars that exhibits a spatially resolved nebulosity in near-infrared scattering light. To directly derive the parameters of a circumstellar disk around FN Tau, observations of dust continuum emission at 340 GHz are carried out with the Submillimeter Array (SMA). A point-like dust continuum emission was detected with a synthesized beam of about 0.7'' in FWHM (Full-Width at Half-Maximum). From the analysis of the visibility plot, the radius of the emission is estimated to be < 0.29'', corresponding to 41 AU. This is much smaller than the radius of the nebulosity, 1.85'' for its brighter part at 1.6 micrometers. The 340 GHz continuum emission observed with the SMA and the photometric data at wavelengths less than 70 um are explained by a power-law disk model whose outer radius and mass are 41 AU and (0.24 - 5.9) x 10^{-3}solar mass, respectively, if the exponent of dust mass opacity (beta) is assumed to be (0-2). The disk model cannot fully reproduce the flux density at 230 GHz obtained with the IRAM 30-meter telescope, suggesting that there is another extended ''halo'' component that is missed in the SMA observations. By requiring the halo not to be detected with the SMA, the lower limit to the size of the halo is evaluated to be between 174 AU and 574 AU, depending on the assumed beta value. This size is comparable to the near-infrared nebulosity, implying that the halo unseen with the SMA corresponds to the origin of the near-infrared nebulosity. The halo can contain mass comparable to or at most 8 times greater than that of the inner power-law disk, but its surface density should be lower than that at the outer edge of the power-law disk by more than one order of magnitude. The physical nature of the halo is unclear, but it may be the periphery of a flared circumstellar disk that is not described well in terms of a power-law disk model, or a remnant of a protostellar envelope having flattened structure.

Keywords: circumstellar matter, submillimeter, protoplanetary disks, pre-main sequence stars, individual (FN Tau)