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Forming localized dust concentrations in a dust ring

DM Tau case study

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ABSTRACT

Context. Previous high-angular-resolution 225 GHz (~1.3 mm) continuum observations of the transitional disk DM Tau have resolved an outer ring at 20-120 au radii that is weakly azimuthally asymmetric.
Aims. We aim to examine dust growth and filtration in the outer ring of DM Tau.
Methods. We performed ~0.″06 (~8.7 au) resolution Karl G. Jansky Very Large Array (JVLA) 40–48 GHz (~ 7 mm; Q band) continuum observations, along with complementary observations at lower frequencies. In addition, we analyzed the archival JVLA observations undertaken since 2010.
Results. Intriguingly, the Q band image resolved the azimuthally highly asymmetric, knotty dust emission sources close to the inner edge of the outer ring. Fitting the 8-700 GHz spectral energy distribution (SED) with two dust components indicates that the maximum grain size ($a_{\rm max}$) in these knotty dust emission sources is likely $\gtrsim$300 μm, whereas it is $\lesssim$50 μm in the rest of the ring. These results may be explained by a trapping of inwardly migrating "grown" dust close to the ring inner edge. The exact mechanism for developing the azimuthal asymmetry has not yet been identified, which may be due to planet-disk interaction that might also be responsible for the creation of the dust cavity and pressure bump. Otherwise, it may be due to the fluid instabilities and vortex formation as a result of shear motions. Finally, we remark that the asymmetries in DM Tau are difficult to diagnose from the $\gtrsim$225 GHz observations, owing to a high optical depth at the ring. In other words, the apparent symmetric or asymmetric morphology of the transitional disks may be related to the optical depths of those disks at the observing frequency.

Key words. Protoplanetary disks – Planets and satellites: formation – (ISM:) dust, extinction – Radio continuum: ISM

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References