

# Forming localized dust concentrations in a dust ring

## DM Tau case study

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### ABSTRACT

**Context.** Previous high-angular-resolution 225 GHz ( $\sim 1.3$  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  $\sim 0''.06$  ( $\sim 8.7$  au) resolution Karl G. Jansky Very Large Array (JVLA) 40–48 GHz ( $\sim 7$  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 ( $a_{\max}$ ) in these knotty dust emission sources is likely  $\gtrsim 300 \mu\text{m}$ , whereas it is  $\lesssim 50 \mu\text{m}$  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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6	2019.	30
7	We performed a $\sim 3''$ angular resolution SMA 200–400 GHz	31
8	survey towards 47 Class II objects in the Taurus-Auriga region	32
9	in 2021 that included DM Tau as one of the target sources.	33
10	We retrieved the archival ALMA Band 3 ( $\sim 95$ –111 GHz),	
11	Band 4 ( $\sim 144$ –159 GHz), and Band 9 ( $\sim 659$ –676 GHz) obser-	
12	vations that the maximum recoverable angular scales (MAS) are	
13	larger than $3''$ for the purpose of deriving the (sub)millimeter	
14	SEDs.	
15	Finally, to reference the locations of spatially resolved fea-	
16	tures in the JVLA observations, we utilized the high-angular-	
17	resolution ALMA 216–233 GHz images towards DM Tau, which	
18	were detailed in Kudo et al. (2018) (c.f. Hashimoto et al. 2021).	
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21	strategy (see details below) using the CASA software package.	36
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