CONTROL ID: 2256118

TITLE: Evidence of fast pebble growth near condensation fronts in the HL Tau protoplanetary disk

ABSTRACT BODY:

Abstract Body: Water and simple organic molecular ice dominates the mass of solid materials available for planetesimal and planet formation beyond the water snow line. Around the condensation fronts of these most abundant volatile species, rapid pebble growth is predicted to occur based on recent numerical simulations of dust coagulation and settling. Here we propose that the dips in interferometric images of the HL Tau protoplanetary disk are due to rapid pebble growth around condensation fronts. HL Tau, a young star in Taurus molecular cloud, was observed by ALMA at 110, 233 and 343GHz continuum bands with spatial resolution as good as 3 AU. We show that the three dips at distances of 13, 32 and 63 AU are spatially resolved and that their center radii are coincident with the expected mid-plane condensation fronts of water ice, ammonia or water-ammonia hydrates, and water-clatherates (with CO2, methane, CO and N2). The 63 AU dip is much wider than the first two and the full extent of the dip also covers the condensation front of pure CO2. The spectral index map of HL Tau between 233 and 343 GHz shows that the flux ratios inside the dip regions are statistically larger than that of nearby regions in the disk. The variation can be explained by a model with two dust populations where most of dust mass resides in the population which has grown into decimeter size scales inside the dips.

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PRESENTATION TYPE: Oral