The Evolution of thermal structure and dust particles in protoplanetary disks considering the shadow formation at the dead zone inner edge

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Planetesimal formation is one of the most important process of planet formation. We expect that dust particles form planetesimals via repetition of combination and fragmentation or the instability at the dust pileup in protoplanetary disks. But the detail process of planetesimals formation is not sure.

We focus on rocky planetesimal formation at the dead zone inner edge. The dead zone is where magnetorotational instability is suppressed. Previous study shows that dust pileup at the dead zone inner edge owing to pressure bump form planetesimals via streaming instability. The results of Monte Carlo radiative transfer simulations show that midplane temperature in the region behind the dust pileup is lower than cases of no dust pileup. The shadow is expected to cause the lower temperature in specific region. A shadow region is behind the dust wall at dead zone inner edge and blocked off the stellar irradiation by the dust wall in disks. Although, calculating midplane temperature using dust surface density with the pressure bump has already done, recalculating the time evolution of dust and gas disk using thermal structure including shadow effect has not done.

In this study, we recalculate the time evolution of dust and gas disk using thermal structure including shadow effect to investigate the scenario suggested by previous study that rocky planetesimals form at dead zone inner edge. We take into radial drift and growth of dust particles account and perform 1D simulations to investigate the time evolution of dust and gas in disks with the dead zone. In addition, we construct new simplified analytical model to calculate midplane temperature by stellar irradiation including shadow effect.

We find that dust pileup outer the pressure maximum at the dead zone inner edge and our results show that dust particles keep growing up there. This is why the lower radial velocity owing to lower temperature in a shadow region cause the dust pileup. In addition, the calculation of dust surface density using thermal structure including the pressure maximum and no shadow shows same result as previous study.

Future, simultaneous calculation of the time evolution of dust and gas disk and thermal structure will allow us to clear the detail process of rocky planetesimal formation.

