Dust evolution in the protoplanetary disk around TW Hya

*Takayuki Matsuura[1], Satoshi Okuzumi[1]

1. Tokyo Institute of Technology

Protoplanetary disks are places of planet formation. Therefore, researching construction and evolution of protoplanetary disks is important when we discuss planet formation. In particular, TW Hya is one of the best interesting stars to understand dust evolution in protoplanetary disks. It is a young star with a protoplanetary disk, and the disk has been observed at various wavelengths due to the good observation condition. Particularly, the latest high resolution imaging observation by ALMA revealed that the disk around TW Hya has gaps at 22 au and 37 au.
Various mechanisms of gap formation have been proposed. One of them is due to gravitational interaction between a planet and a disk. Accordingly, considering existence of planets, simulations on disk evolution are carried out. Those simulations show that dust is depleted and a gap forms at planetary orbit. However, the results of the simulations have different tendencies compared with the observation by ALMA, such as dust inside a gap is less than outside, and much dust accumulates on an outer edge of a gap.
Therefore, in this study, we aim to clarify what kind of physical characteristics the disk around TW Hya has in order to reproduce the dust distribution of TW Hya. For that, we simulate dust evolution in a disk and search for parameter ranges that reproduce the radial distribution of brightness temperature and spectral index obtained by ALMA. We assume that planets exist at 22 au and 37 au. We set the planet masses and the fragmentation velocity of dust to free parameters.
As the result, when the planet masses are 4—10 earth masses and the fragmentation velocity is 0.5 m s^{-1} , the simulation result reproduces observation by ALMA roughly. When we assume faster fragmentation velocity than the value that reproduce observation, dust is depleted inner the gap and more dust accumulates on the outer edge of the gap. When we assume heavier planets, more dust accumulates on the outer edge of the gaps and the contrasts of the gaps grow in excess. Thereby the observation is not reproduced.
The fragmentation velocity obtained in this study is slower than the value that has considered from a conventional growth theory of dust in disk. That suggests a possibility that monomers composing dust are large size of 10 μm or more(Wada et al.,2013), or monomers are covered by CO_2 ice(Musiolik et al.,2016). Additionally, the result suggests a possibility that planetesimals formed with the assumption different form scenario that dust coalesces into planetesimals.

Keywords: protoplanetary disk, TW Hya

