Possibility of giant planet formation by pebble accretion in Class 0/I YSOs

*Yuki Tanaka[1], Yusuke Tsukamoto[2]

1. Tokyo Institute of Technology, 2. Kagoshima University

Recently, pebble accretion in protoplanetary disks attracts attention in theoretical works of planet formation. In this process, it is thought that cm-sized particles, so-called pebbles, drift inward in the disk, and growth of planets will be accelerated due to accretion of pebbles onto proto-planets. Various theoretical works which assume pebble accretion, such as giant planet formation and formation of super-Earths systems, have been done so far.

Meanwhile, recent radio observations by ALMA have revealed that existence of clear gaps and rings in many very young protoplanetary disks. Mechanisms to generate these structures of gaps and rings are yet to be investigated, and many theoretical models have been proposed. One of these hypotheses is that gas giants in the disks carve gaps in the dust disks and create such structures. Numerical simulations which assumed the existence of the planet have been shown that gaps and rings similar to the observations can be represented. However, a time-scale for planet formation will be long because the observed radii of gaps and rings are relatively large, so it is unclear whether the planet with enough mass to create a gap can form in very young disks.

Here we focus on planet formation in much earlier stages, Class 0/I phases. Combining an analytical model of a gravitationally unstable disk around Class 0/I YSOs with a model of pebble accretion, we investigate possibility of giant planet formation in the early stages of disk evolution. We find that in many cases a time-scale of pebble accretion in the condition of Class 0/I YSOs is much shorter compared to that in a typical protoplanetary disk, because of larger mass accretion rates. We also find, however, the accretion time-scale is not always a decreasing function of the gas accretion rate, and the time-scale can be longer as the increase of the gas accretion rate depending on parameters. Using derived time-scales, we investigate growth of proto-planets with different parameters such as the gas accretion rate and dust-to-gas mass ratio. Based on our results, we discuss a required initial mass of the proto-planets to form cores of the giant planets within Class 0/I phases.

Keywords: Planet formation, Protoplanetary disk, Pebble accreton, Class 0/I YSOs

