Test of a model for the gas accretion onto giant planets by two-dimensional hydrodynamical simulations

*saho nakazawa[1], Yuki Tanaka[1], Hidekazu Tanaka[1]

1. Tohoku University

Giant planets are generally considered to have formed by capturing disk gas in a protoplanetary disk. However, we do not have a reliable model which predicts an accurate gas accretion rate onto a planet for a given disk. Without such a model, we cannot fix the growth time and final mass of giant planets.

Because of its strong gravity, a giant planet excites density waves and creates a gap (i.e., a low-density annular region) along the planetary orbit. Tanigawa & Tanaka (2016) constructed a model of the gas accretion rate onto a planet, by assuming that the gas accretion rate is proportional to the gas surface density in the gap. Although their model is almost consistent with some three-dimensional hydrodynamic simulations, the accuracy of the model is still uncertain. In this study, we test their model in detail , by performing two-dimensional hydrodynamic simulations with FARGO code.

First, we perform test simulations of gap formation without gas accretion onto the plant for various planet masses and viscosities. Then, we confirm that our results are consistent with an empirical formula of gap depth derived by Kanagawa et al. (2015).

In the simulations with the gas accretion onto the planet, we model the gas accretion onto the planet, by reducing the gas surface density in the accretion region around the planet with a certain reduction timescale. Then, we have three parameters, i.e., the radius of the accretion region, the reduction timescale, and the smoothing length in the planetary gravitational potential. We perform simulations with various values of these parameters and find that the gas accretion rate is almost independent of the radius of accretion region and the smoothing length, if these are less than the disk scale height. Although the gas accretion rate depends on the reduction timescale, it converges for a short reduction timescale. Furthermore, we compare our converged accretion rate with the model by Tanigawa & Tanaka (2016) and find that our results are consistent with their model for various viscosities.

Keywords: planet formation, gas accretion, hydrodynamics