平成 21 年度国立天文台天文シミュレーションプロジェクト成果報告書

有無自己重力の微惑星円盤による惑星と小天体の軌道進化

Patryk Sofia Lykawka (近畿大学)*

利用カテゴリ　　　汎用 PC

*formerly 神戸大学.

I have performed a vast number of computer simulations during the fiscal year Heisei 21. Worth noting, this research topic represents a completely new and the most comprehensive work ever done on the dynamics of the asteroid belt, Kuiper belt, and planets during the early solar system using massive planetesimal disks with and without self-gravity. Therefore, the various results from these calculations will render a number of publications in international refereed journals and conferences over the course of 2010/2011. More details on the importance, current status and preliminary results are shown below.

Dynamical evolution of planets and small bodies in massive planetesimal disks with and without self-gravity

I aim to investigate the dynamical outcomes of the four giant planets during the early solar system right after the break up of their mutual orbital resonant configurations. In particular, it is important to understand what the typical outcomes are, and which hints these results can provide for the early evolution of the solar system and extrasolar systems. In addition, it is also interesting to investigate the role of particular mutual resonances among the planets and the influence of massive planetesimal disks on the orbital evolution of giant planets and small body reservoirs, such as the asteroid and Kuiper belts. In particular, since self-gravity is also taken into account, I stress this is very unique as it still remains an unexplored topic in planetary sciences.

In this project, I chose to investigate various systems including massive disks with and without self-gravity and the four giant planets. In some cases, even the terrestrial planets were taken into account in the calculations. In addition, I also considered the presence of both the asteroid and Kuiper belts. Thus, all these calculations provide a virtually complete picture of the early evolution of the solar system. To provide statistically meaningful results and recalling the stochastic behaviour of such systems, I decided to perform 5-10 simulations of each specific initial configuration for all systems. Unfortunately the vast number of initial conditions and the very computer-consuming simulations of disks with self-gravity did not allow me to finish all the runs by the end of the year Heisei 21. Therefore, a fraction of these simulations, in particular, are still running at the moment (but should be completed by the end of the current fiscal year).

I performed tens of simulations of systems using massive planetesimal disks with self-gravity, and a few hundreds of simulations for systems that included similar disks, but without self-gravity. These simulations covered four main initial configurations for the giant planets and two typical disk total masses (low and high disk mass). The disks were composed of 10000 and 2000-5000 bodies for the cases of disks without and with self-gravity, respectively. In all simulations the systems evolved over 20-100 Myr. After that, I chose a significant number of representative simulations and evolved them over 4 Gyr, roughly the age of the solar system.

Most of the simulations were completed recently, while others are still ongoing (those that consider disk self-gravity). Thus, unfortunately I have not started analyzing the output data so that I am unable to show the preliminary results at the moment. However, considering the volume of data obtained from the comprehensive simulations described in this project, I anticipate that several papers will be a natural outcome over the next 1-2 years.