博士学位论文摘要选登

原行星盘对行星系统形成及演化的影响

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系外行星的探测是近年来炙手可热的话题，尤其是类地行星的探测．随着观测数据的不断积累，以及 NASA 的 Kepler 卫星的升空，越来越多的系外行星系统和类地行星被探测到，这将极大地丰富系外行星和系外行星系统的样本，为我们提供更多的素材，使我们对系外行星的形成、演化等过程有更加深刻的认识．

根据现有的行星形成理论，行星是在原行星盘中形成的，而原行星盘对原行星的影响在行星形成和演化过程中至关重要．正是原行星盘的多样性造就了系外行星系统的多样化．我们考察了行星形成的后期，当气体盘尚未消散，火星质量大小的星胚已经形成后，星胚相互之间的引力作用明显，能够激发相互的偏心率，或者碰撞并合，同时在气体盘的潮汐力矩作用下，它们的 I 、 II 型轨道迁移以及轨道圆化等过程都会很大程度上影响最后形成的行星系统．

第 1 章我们介绍了目前系外行星探测的主要方法，并且介绍了 Kepler 空间望远镜上天之后，取得的一些新成果．列举了一些具有典型代表性的行星系统，以此说明系外行星系统的多样性．第 2 章我们主要叙述了现有的行星形成理论，包括引力不稳定性模型和核吸积模型，着重介绍目前主流的核吸积模型．

第 3 章我们主要考察一个非自引力的粘滞盘与行星的相互作用，包括 I 、 II 型轨道迁移，轨道圆化，以及大质量的行星核吸积气体等因素，采用严格的 N 体模拟，考察不同的原行星盘对行星的形成过程乃至最终构型有怎样的影响．第 4 章采用蒙特卡洛法，根据原行星盘的观测结果，考虑原行星盘的参数分布，从统计上与观测结果作比较，比较好地解释了观测上行星的一些分布结果，并且能指导进一步的观测．

鉴于 I 型迁移速度，甚至方向的不确定性，第 5 章我们考察了一维气体盘上由于扰动产生密度波后，低质量行星在盘上迁移的模型．我们给出了位于不同相位角中行星的总力矩变化情况，并且考虑到密度波的传播与行星的偏心率轨道，给出了在特定情形下，行星向外或者向内迁移的判据．

考虑到气体盘的自引力作用，第 6 章介绍了一个一维的准静态自引力盘模型，并且考察了气巨星在其中打开空隙的情形，我们发现气巨星打开的空隙宽度和气体面密度有关，面密度越大，空隙宽度也越大．对比非自引力盘的结果，我们发现当气体盘密度低于临界值时，自引力盘中的空隙宽度反而小于非自引力盘．文章的最后，我们总结了自己的工作并做了详细讨论．

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The Key Roles of the Gas Disk in the Formation and Evolution of Planetary Systems

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The detection of exoplanets becomes hotter and hotter, especially the detection of Earth-like exoplanets. With the accumulation of observational data and the progress of Kepler mission of NASA, more exoplanets can be found or confirmed. The understanding of formation and evolution of exoplanets will be largely improved when much more samples are provided.

According to the acknowledged theories of planet formation, the protoplanet is formed in the protoplanetary disc. Due to the interactions between the disc and protoplanets, the property of the disc plays a key role during the formation and evolution of planets. We investigate the later stage of planet formation, when the Mars-sized cores appear and the gas disc has not been depleted yet. Interactions among the planetary cores can excite their orbital eccentricities, accelerate their mergings, and thus sculpture their final orbital architecture. The interactions between the cores and gas discs lead to the type I and II migrations as well as the eccentricity damping. However, the rates of type I, II migrations are still uncertain in different disc models.

In chapter 1, we introduce the main methods of exoplanet detection and the achievements of Kepler space telescope. We also list some examples of exoplanetary systems to show their diversity. The acknowledged theories of planet formation, including the gravitational instability and core accretion scenarios, are presented in detail in chapter 2.

The studies in chapter 3 contribute to the final assembling of planetary systems with N-body simulations, including the type I and II migrations of planets, the eccentricity damping, and the gas accretion of massive cores in a viscous disk. In order to compare the observations in statistics, we use the Monte Carlo method to set a distribution of different discs. Our results of simulations interpret the distribution of exoplanets and may be a guidance for the further observations.

In chapter 5, considering the uncertainty of the rate or even the direction of type I migration, we choose a one-dimensional model of the gas disc, adding a density wave due to some perturbations, to survey the migration of low mass planets. The total tidal torques on the planets depend on their phase angle. Adding the propagation of density wave and the eccentric orbit of planet, we find an outward/inward migration criterion for a planet in given conditions.

After the formation of a gas giant, the tidal torque leads to a gap-opening in the disc around the giant. Chapter 6 provides a one-dimensional quasi-steady self-gravitational disc model. In this model, there is a positive correlation between the gap width and the surface density of gas disc. Comparing to the non-self-gravitational disc model, when the surface density is smaller than the critical surface density, the gap width in self-gravitational disc model becomes narrower than that in the non-self-gravitational disc model. In final chapter, we summarize our results and make some discussions.