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Formation of Terrestrial Planets form Protoplanets: The Basic Scaling Laws

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The final stage of terrestrial planet formation is known as the giant impact stage where lunar-to-Mars-sized protoplanets collide with one another to form planets. We have been investigating this final assemblage of terrestrial planets from protoplanets using N-body simulations. As initial conditions, we adopt the oligarchic growth model of protoplanets. We systematically change the initial protoplanet system parameters. For each initial condition, we perform more than 20 runs, and from their results we derive the statistical properties of the assembled planets. For the standard disk model, typically two Earth-sized planets form in the terrestrial planet region. We present the basic scaling laws of terrestrial planet formation with the initial protoplanet system parameters. The number density of planets slowly decreases as the total mass of initial protoplanets increases, while the mass of individual planets increases almost linearly. The spin obliquity is well expressed by an isotropic distribution. The typical spin angular velocity is given by the critical spin angular velocity for rotational instability under the assumption of perfect accretion in collisions. We also discuss the effect of the accretion condition on the terrestrial planet formation.

Keywords: terrestrial planets, formation, solar system