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A New and Advanced Approach to the Formation and Composition of Terrestrial Planets

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We present the results of a new and comprehensive approach to simulating the formation of terrestrial planets. Our approach begins with simulating the collisional growth of the first planetesimals and continues with resolving giant impacts using our state-of-the-art SPH-based model. We take into account all relevant physical processes including the dynamical friction due to the debris and planetesimal disks, migration of planetesimals and embryos, and the perturbation as well as possible migration of giant planets. Also, for the first time, we consider a more realistic protoplanetary disk where the distribution of planetesimals and planetary embryos are not approximated by a mathematical function, but instead contain depletions and inhomogeneities. Results point to several important findings. In the context of our solar system, almost all simulations produced an Earth-analog. Also, Mars-analogs appeared routinely in regions with local density depletions where the disk lacked material. These results seem to imply that the formation of Earth could have been due to the natural dynamical evolution of the protoplanetary disk and the small mass of Mars seem to be due to the non-uniform distribution of the disk material. Simulations also show that the capture into resonance of migrating giant planets does not play a significant role on the formation of rocky planets. Super-Earths are formed routinely when giant planets migrate. In regard to the composition of terrestrial planets, our results suggest that while giant planets may affect the inventory of planet-forming material, they play no role in the mechanics of the formation of rocky planets and the transfer/transport of chemical compounds to them. Formation and delivery of chemical compounds are merely due to the mutual interactions of planetary embryos, a process that occurs even when no giant planet exists. We will present the results of our study and discuss their applications to the formation and composition of terrestrial planets in our solar system and extrasolar planets.

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