Terrestrial Planet Formation: Constraining the Formation of Mercury

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The formation of Mercury remains poorly understood. Importantly, previous works have not considered the formation of Mercury in the context of formation of the other terrestrial planets.

We investigated terrestrial planet formation by performing N-body simulation runs using hundreds of embryos and thousands of disk planetesimals representing a primordial protoplanetary disk. To investigate the formation of Mercury, these simulations considered an inner region of the disk (the Mercury region) and disks with and without mass enhancements beyond the ice line location in the disk.

Although Venus and Earth analogs (considering both orbits and masses) successfully formed in the majority of the runs, Mercury analogs were obtained in lesser runs. Our Mercury analogs concentrated at orbits with semimajor axes slightly smaller than that of Mercury (a = 0.39 au), relatively small eccentricities/inclinations, and median mass m ~ 0.2 Earth masses with variations within a factor of a few. In addition, we found that our Mercury analogs acquired most of their final masses from embryos/planetesimals initially located between the disk inner edge and ~1–1.5 au within 10 Myr, while the remaining mass came from a wider region up to ~3 au at later times. These results suggest that to reproduce the orbit and mass of Mercury, the protoplanetary disk should have an inner edge at a 0.3 au with mass peak located beyond 0.6 au. Also, the Mercury region should be mass depleted.

Keywords: planet formation, inner solar system, terrestrial planets, Mercury, solar system

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