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Combined giant and terrestrial planet formation in the Solar System

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The formation history of Jupiter has been of interest due to its ability to shape the solar system's history. Here we explore through N-body simulations the implications of the simplest disc and pebble accretion model with steady-state accretion and an assumed ring structure in the disc at 5 au on the formation of the giant planets in the solar system. The probability distribution of the final location of the giant planets is approximately constant in log *r*, suggesting there is a slight preference for formation closer to the Sun, but no preference for more massive planets to form closer. We compute the average formation time for proto-Jupiter to reach 10 Earth masses to be 1.1 ± 0.3 Myr and for proto-Saturn 3.3 ± 0.4 Myr, while for the ice giants this increases to ~5 Myr. The formation timescales of the cores of the gas giants are distinct at confidence, suggesting that they formed sequentially.

The forming gas giants scatter the planetesimals in their vicinity, some of which are parked in the terrestrial planet region through gas drag, which changes the isotopic composition of the terrestrial planets. After 5 Myr of evolution approximately 25% of the mass of planetesimals in the Jupiter-Saturn region is implanted in the inner solar system. The planetesimals that remain in the inner solar system have a mixed isotopic composition. The implantation initially sets up a composition gradient in the inner solar system, with the mass-weighted fraction of outer solar system material peaking near 1 au from the Sun. The planetesimal disc in the vicinity of the gas giants may not have been very massive, ~1 Earth mass . The inner planetesimal disc may not have extended much farther than 2 au, otherwise embryos do not grow fast enough to produce Mars analogues. This could mean that the region of the current asteroid belt never contained much mass to begin with.

References

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