Study of solid accretion in mean motion resonances with gas giants via N-body simulations: Toward understanding the formation of Uranus and Neptune

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The formation process of Uranus and Neptune is important for understanding the origin of such exoplanets.
The current picture of the formation of Uranus and Neptune

In a promising formation scenario of Uranus and Neptune...

**Giant collision between planetary embryos**

Planetary embryos a few $M_\oplus$

How did such embryos accrete in the early Solar system?
A possible model

1. The accretion of planetesimals trapped in mean motion resonances (MMRs) with inner giant planets

2. The formation of Embryos near MMRs

3. Giant collisions of embryos after gas dissipation
   - After disk gas dissipation, the proto-embryo system becomes dynamically unstable, leading to collisions of embryos.

4. The formation of core of Uranus and Neptune
To investigate
- The effect of MMRs with inner giant planets on planetary accretion
- The dynamics of embryos in MMRs in the presence of disk gas

Initial condition

2D N-body simulation.
Planetesimals (N=1000, $m_0 \sim 9.0 \times 10^{25}$ g) are distributed in a 2D ring (6.5 - 15 AU) with Jupiter.
In accordance with Beaugé et al. (1994), the following interactions are considered:
- Mutual gravitation between planetesimals
- Gravity of Jupiter and Sun
- Gas drag (which we have enhanced for saving the computational time)
Large embryos (~ $10^{28}$g) are formed through accretion of planetesimals near the MMRs.

In my result, instead of giant collisions, embryos undergo mutual gravitational scattering.

In Beaugé et al. (1994), giant collisions of the embryos occurred in the presence of the disk gas.

We conclude that before gas dissipation, giant collisions of large embryos near MMRs do NOT always occur.