Melting the core of giant planets: consequences for tidal dissipation in their interiors

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Abstract:

Giant planets are believed to host central dense rocky/icy cores that are key actors in the core-accretion scenario for their formation. In the same time, some of their components are unstable in the temperature and pressure regimes of central regions of giant planets and only ab-initio EOS can address the question of the state of matter. Finally, several works demonstrated that erosion and redistribution of core materials in the envelope must be taken into account.

These complex mechanisms thus deeply modify giant planet interiors for which signatures of strong tidal dissipation have been obtained for Jupiter and Saturn. The best candidates to explain this dissipation are the viscoelastic dissipation in the central dense core and turbulent friction acting on tidal inertial waves in their convective envelope. In this work, we study the consequences of the possible melting of central regions for the efficiency of each of these mechanisms.

The studied set-up:

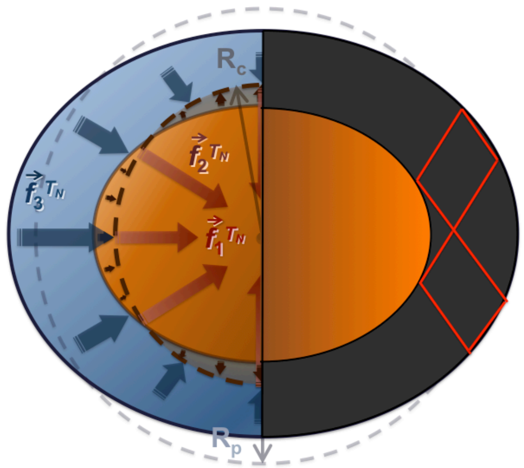

Fig 1: Two-layer giant planet of mass M_p and mean radius R_p. The dense central core of radius R_c, mass M_c and density ρ_c is surrounded by a convective envelope of density ρ_e. Tidal dissipation must be studied both in the central (viscoelastic rocky/icy) dense core (left) and in the external turbulent convective envelope where inertial wave attractors (in red) may appear (right).

Key results

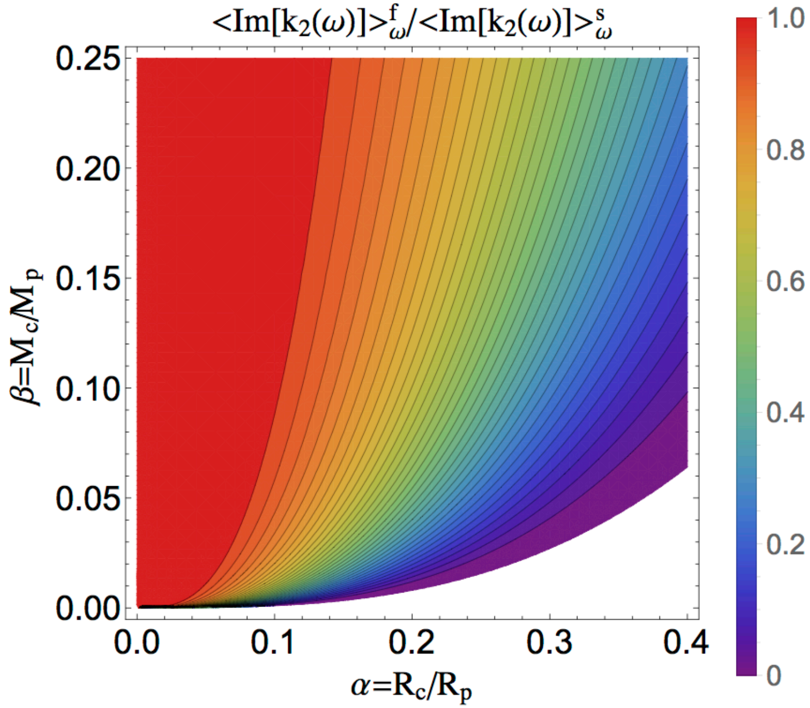

Fig 2: Ratio of the frequency-averaged tidal dissipation at fixed angular velocity due to turbulent friction acting on inertial waves in an external convective envelope surrounding a central molted liquid (^{f}) or a solid core (^{s}) as a function of aspect and mass ratios ($\alpha=R_c/R_p$ and $\beta=M_c/M_p$ respectively).

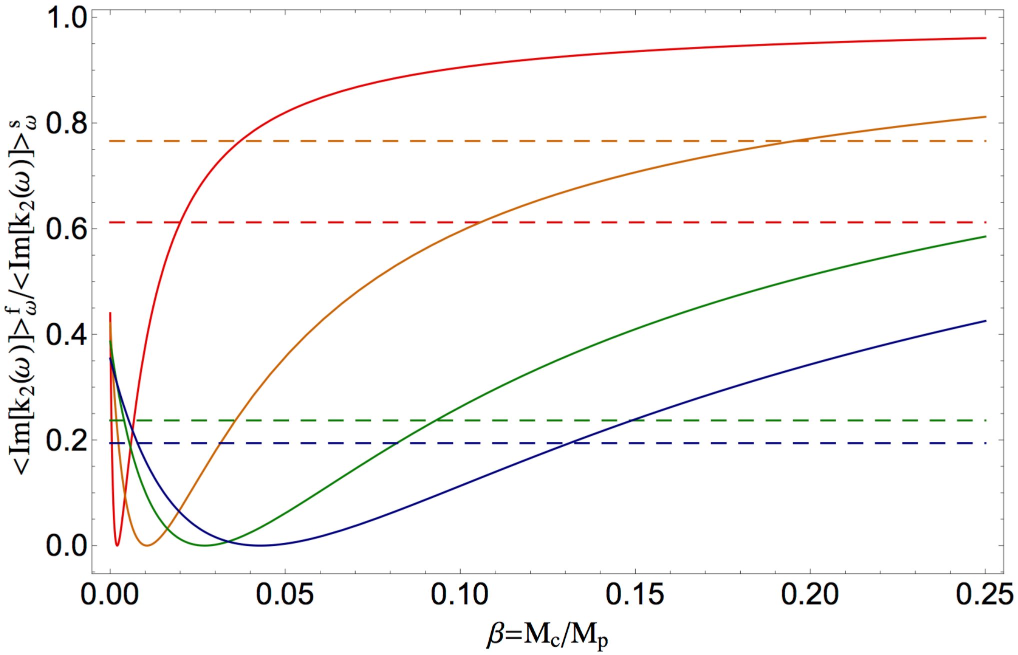

Fig 3: Evolution of this ratio as a function of $\beta=M_c/M_p$ for Jupiter-like (red line; $\alpha=0.126$), Saturn-like (orange line; $\alpha=0.219$), Uranus-like (green line; $\alpha=0.30$) and Neptune-like (dark blue line; $\alpha=0.35$) planets.

Conclusion:

- Tidal dissipation in the gaseous envelope (and in the core) may decrease because of the melting;
- This decay may be stronger for icy than for gaseous giant planets.

Bibliography:

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