Implications of Mercury’s core composition on its libration and present-day thermal state.

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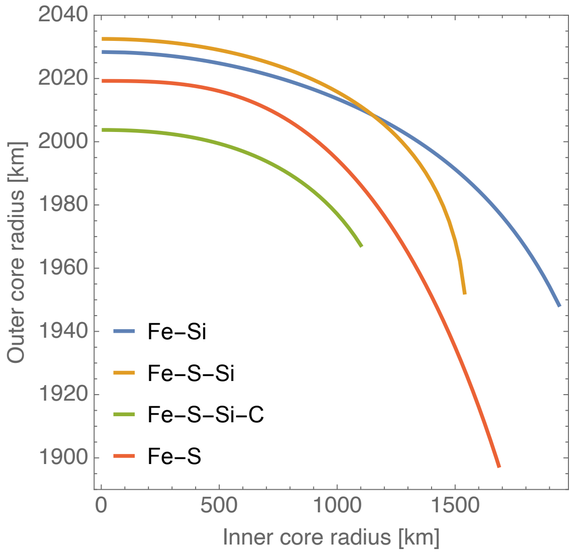
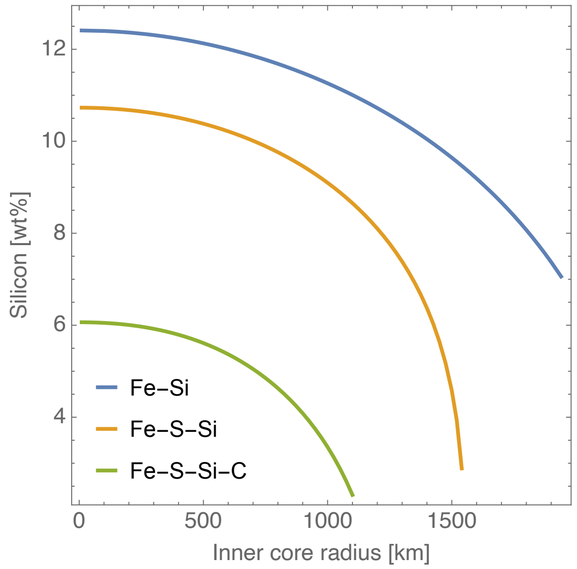
Core composition

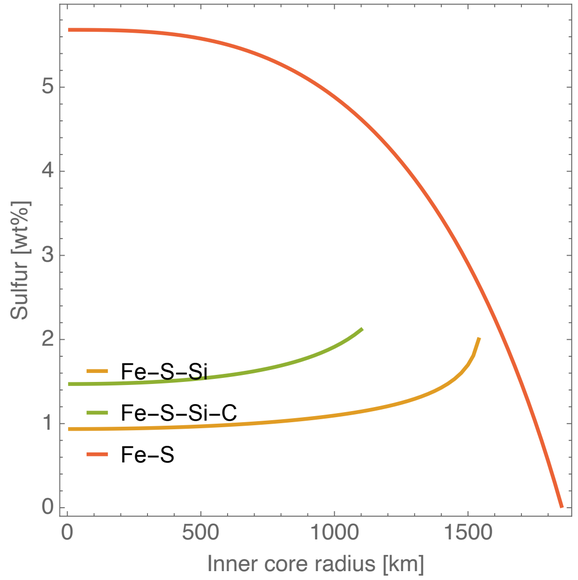
- reducing formation conditions -> candidate light elements in decreasing order of occurence: Si, S, C
- unlike Si, S, and even more C have a strong effect on the core liquidus
  -> effect on r_{icb}- r_{cmb} relation
- Si, S, and C partition differently between solid and liquid Fe a substantial effect on ICB density jump $(D_{\mathrm{S}}^{\mathrm{sol/liq}} \sim 0., D_{\mathrm{Si}}^{\mathrm{sol/liq}} \sim 1., D_{\mathrm{C}}^{\mathrm{sol/liq}} \sim 0.3)$
- expect effect of core composition on Mercury's librations

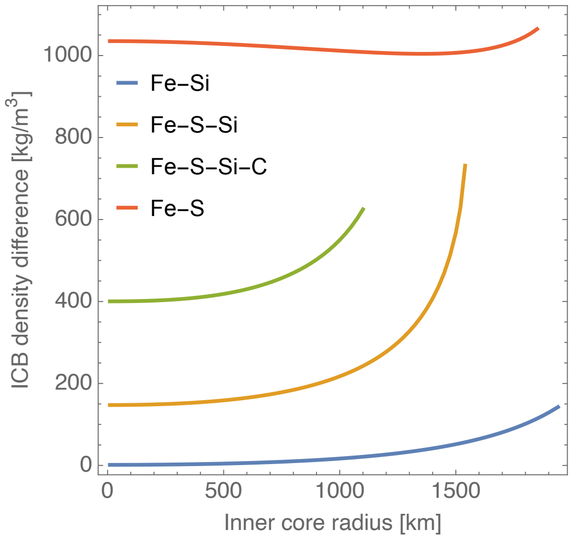
Interior structure models

- assume fixed crust, olivine-pyroxene mantle aggregate, T_{cmb}=1850 K, liquid Fe-S-Si-C outer core, and solid Fe-Si-C inner core, core liquidus parameterisation based on existing Fe-S, Fe-Si, and Fe-C phase diagrams and melting data
- models agree with mass and moment of inertia and Si < Fe-Si eutectic (12.5wt%), 3 core compositions



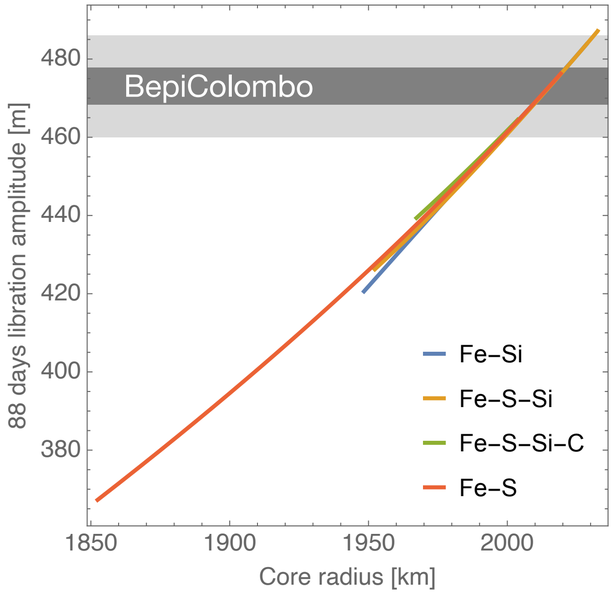


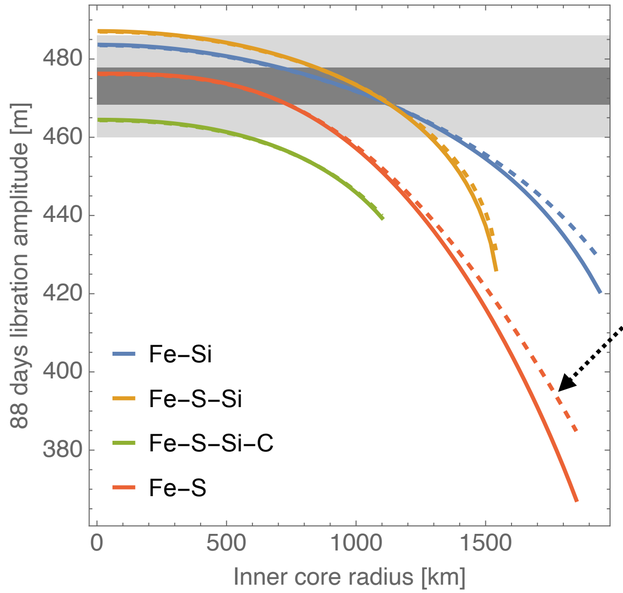




- core radius decreases with inner core radius (mass conservation) and rate depends on core composition
- inner core radius decreases with amount of light elements and the functional relation is determined by the core liquidus, light element partitioning behaviour, and equation of state

88 days libration amplitude



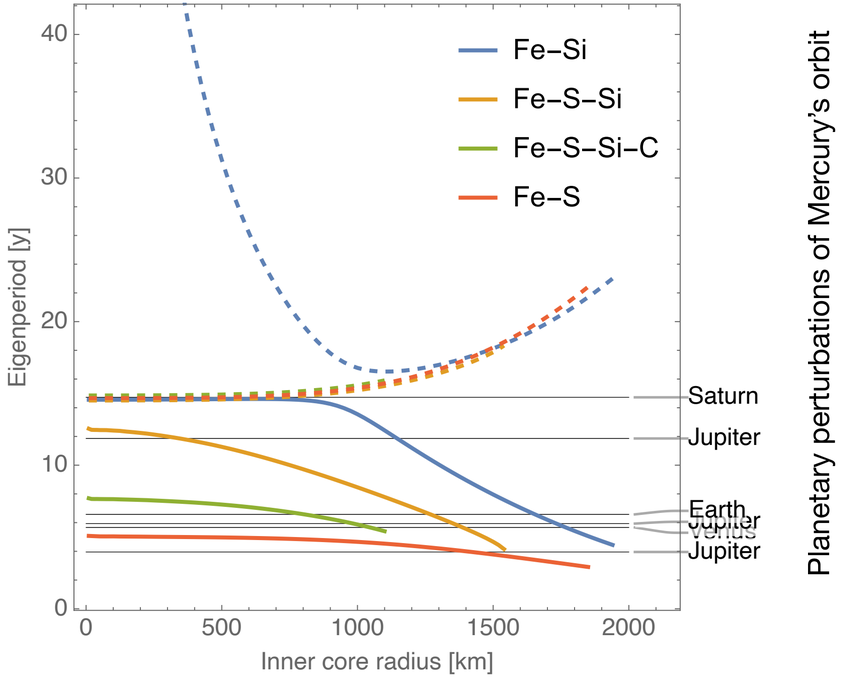


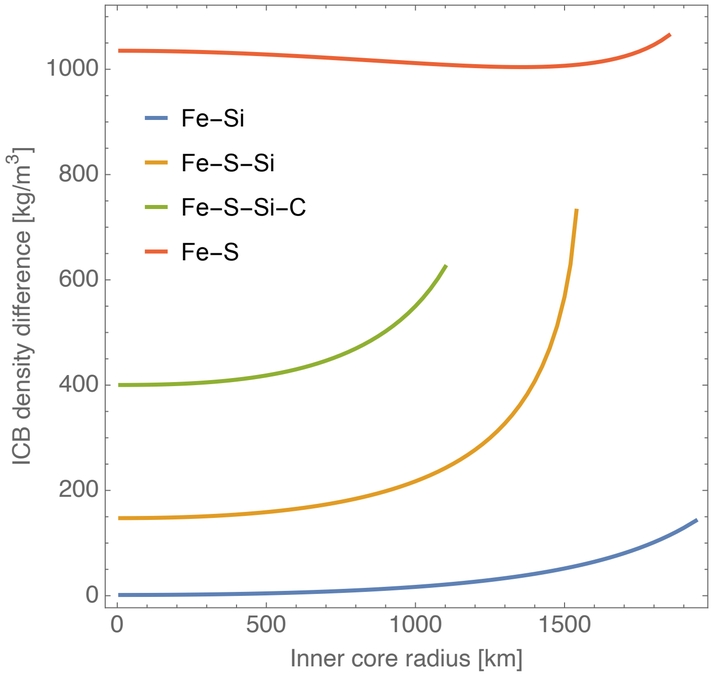
gravitational coupling neglected

- libration amplitude increases with core radius and decreasing mantle moment of inertia, but specific core compositions have only a small effect → 88d libration amplitude is a robust estimate for the core radius
- gravitational coupling between inner core and mantle increases with density difference at inner core-outer boundary (largest for Fe-S-Si-C) but likely only detectable by BepiColombo if inner core radius >1000km
- inner core radius can only be constrained from libration amplitude with prior knowledge about core composition and thermal state

Free libration modes

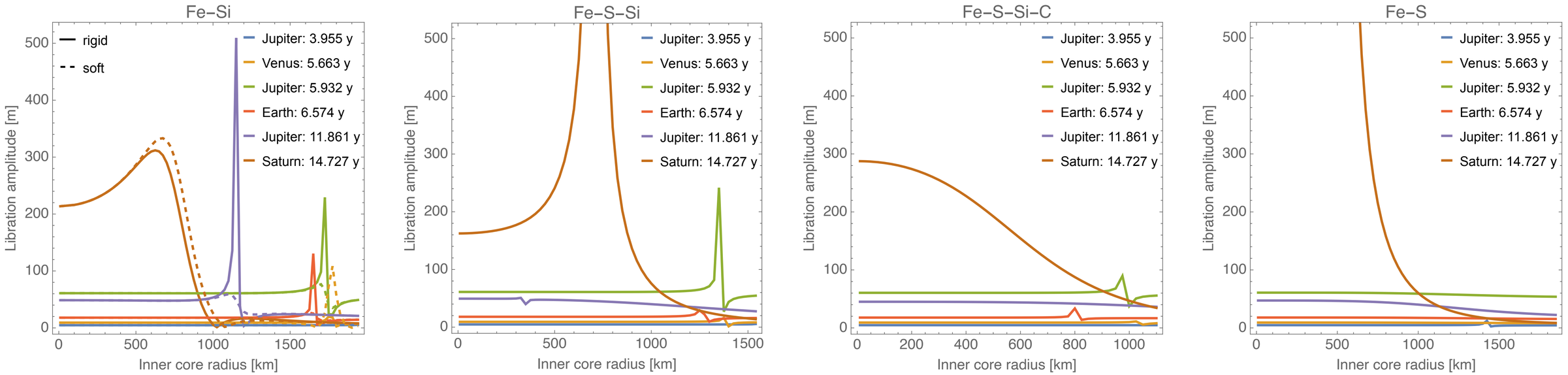
- gravitational oscillation of the combined figures of the mantle and inner core → **F**ree **M**antle–**I**nner **C**ore mode (FMIC)
- mutual out-of-phase gravitational oscillation between inner core and mantle → **M**antle-**I**nner **C**ore **G**ravitational mode (MICG)





- core composition has a significant effect on the period of the 2 libration normal modes
- FMIC increases with inner core radius, expect for Fe-Si models where it decrease initially until the inner ≳ 1200km
- MICG decreases with increasing inner core radius and increasing density contrast between solid and liquid core
- several long period forced libration can be resonantly amplified for small or large inner core radii

Long period forced libration amplitudes



- if the inner core radius ≲ 1000km the 14.7y libration can be significantly affected
- shorter period librations are only amplified for a narrow inner core radius range
- viscous/electromagnetic and/or soft inner core can shift periods of eigenmodes and and broaden “resonance” peaks
- libration amplitudes can be significantly damped if the inner core is soft