Tidal dissipation in stars and fluid planetary layers and their impact on the evolution of star-planet systems

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Abstract

Tidal dissipation in stars and planets is one of the key physical mechanisms that drive the evolution of planetary systems. It intrinsically depends on the nature of the tidal response of celestial bodies, which is directly linked to their internal structure and rheology. Indeed, the internal dissipation is strongly different in the cases of solids and fluids, with a highly resonant response in the case of fluids. In the first part of this talk, we will present a local analytical modelling of gravito-inertial waves, which can be excited by tides in stars, in the deep fluid envelope of giant planets and in the core and the atmosphere of telluric planets. This model allows us to understand the properties of the resonant tidal dissipation of these waves as a function of the excitation tidal frequencies, the rotation, the stratification, and the viscous and thermal properties of the studied fluid regions. Then, the frequency, height and width of the dissipation resonances as well as the non-resonant equilibrium tide will be derived analytically in asymptotic regimes that are relevant in planetary and stellar interiors. Next, we introduce such a complex tidal dissipation spectra in a celestial mechanics numerical code to give a qualitative overview of its impact on the evolution of planetary systems. We consider the theoretical example of a two-body coplanar system with a central fluid body excited by a punctual perturber. We demonstrate how the viscous dissipation of tidal gravito-inertial waves can lead to a strongly erratic orbital evolution. Finally, we characterise such non-regular dynamics as a function of the height and width of resonances, which have been previously studied thanks to our local fluid model.

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