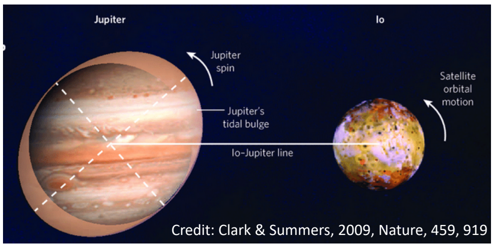
PhD project, Prof. Caroline Terquem, caroline.terquem@physics.ox.ac.uk



Credit: Clark & Summers, 2009, Nature, 459, 919

Interaction between tides and convection with application to solar type stars and giant planets

Astrophysical context:

Stars are often found in binary systems. When the separation between the two stars is small enough, oscillations are excited in each of the stars by the tidal potential of its companion. These tidal waves are dissipated in the convective regions of the stars, resulting in the **circularisation of the orbits**. Observations show that close orbits are circular whereas wider orbits have eccentricities. The period at which the transition occurs for a type of stars is called the *circularisation period*.

Similarly, tides are excited in **giant planets** by their close satellites, and are dissipated in the convective atmosphere of the planets. This yields an **evolution of the orbits** of the satellites which has been measured.

1

Interaction between tides and convection:

So far, all the studies of the interaction between tides and a convective flow assume that the large scale tides can be described as a mean shear flow which is damped by small scale fluctuating convective eddies. This yields a tidal dissipation rate several orders of magnitude too small to account for the circularization periods of late–type binaries or the tidal dissipation factor of giant planets.

We have recently argued that the above description is inconsistent, because fluctuations and mean flow should be identified based on the timescale, not on the spatial scale, on which they vary. Therefore, the standard picture should be reversed, with the fluctuations being the tidal oscillations and the mean shear flow provided by the largest convective eddies. Crude estimates indicate that this new formalism may yield rates of energy dissipation in agreement with observations for fully convective bodies.

However, the energy dissipation rate is still about 40 times too small to account for the circularization periods of late–type binaries.

2

Project:

Several questions could be investigated as part of a PhD project.

In stars which are not fully convective, the results mentioned above indicate that tidal dissipation is probably not due to dissipation of the standard equilibrium tide in convective envelopes. The shear in the tachocline may be the main source of dissipation, and this could be investigated.

The new formalism described above has been developed for incompressible tides. This is a good approximation for low frequency gravity modes, but not for pressure modes, as observed in the Sun. The project could involve extending the formalism for compressible modes, which would make applications to helioseismology possible.

Other avenues could be explored, depending on the interests of the student.

Pre-requisite:

Some knowledge of fluids is required. The project will involve analytical and numerical tools. No extensive knowledge in computational methods is required, as the project could take different directions depending on the skills of the student.