

MagIC to simulate tidal flows in stellar or planetary convective shells

Tidal interactions play a crucial role in shaping the orbital architecture and rotational evolution of close stellar and planetary systems. The dissipation of the tidal flow energy within the fluid convective envelopes of stars and planets is an efficient way of exchanging angular momentum in these compact systems. Although magnetism and differential rotation are likely to be ubiquitous in the convective region(s) of host solar-like stars and giant gaseous planets, most studies give tidal interaction predictions based on linear 2D hydrodynamic models using uniform rotation.

Our goal is to provide a comprehensive 3D numerical model of tidal flows and their dissipation in stellar and planetary convective envelopes, adapted to the complexity and specificity of host stars and their planets. We have modified the MHD pseudo-spectral and open-source code MagIC, in order to implement and study tidally-excited waves in 3D spherical convective shells subject to nonlinear effects, differential rotation, and magnetism. Using hybrid (both OpenMP and MPI) parallelisation on supercomputers (especially the DiRAC HPC UK national facility), we are able to explore the parameter space (tidal amplitude, frequency, convective envelope size, and viscosity) to investigate how hydrodynamical tidal dissipation estimates differ from prior 2D linear predictions. In these simulations, we also characterise the strong coupling (including instabilities) between tidal waves, tidally driven axisymmetric zonal flows, and ultimately magnetic field.