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Analytical expression of the topographic torque on the CMB

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We have computed the pressure torque on the topography at the core-mantle boundary. This torque can be decomposed into three parts: (1) the constant part of the torque at equilibrium (without additional mantle and core rotations; this part is not interesting in our context), (2) the torque due to the inertial rotation pressure (related to the non-Poincare part of the fluid on the topography, and (3) the torque due to the inertial rotation pressure on the topography related to the Poincare part of the fluid. The two last parts of the total torque involve the coefficients of the development of the topography in harmonics. Only these two last parts are of importance when computing the effects of a perturbing potential and related additional rotations for the core and the mantle.
The philosophy of the computation follows Wu and Wahr (1997, GJI 128, 18) and consist in introducing a scalar function χ in the Navier-Stokes equation and in separating it into two equations of which the solutions can be computed analytically. With the choice for one of the velocity field to be the Poincare fluid, both parts of the velocity field are incompressible. The boundary conditions at the CMB are imposed on the total velocity and yield thus an additional important relation involving the analytical expressions of the velocity fields and the topography coefficients. This allows to solve for the velocity field coefficients in terms of the topography coefficients.
We have found that there are particular topography coefficients that are enhanced due to the cross-coupling between different spherical harmonics. This is very important as the total torque is thus shown to be dependent on the geometry and on particular amplitudes of the topography. This was previously shown with an example in Wu and Wahr, but here we show that this is not an artifact from the choice of the topography but rather a general fact.