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Properties of the Quasi-Free-Decay Magnetic Modes: Application to the Earth's outer core

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This work focus on one particular family of solutions (u, b) of the full MHD wave equations in spherical shell geometry, by considering a solid body rotation and an axisymmetric background magnetic field as background state. These non-axisymmetric waves are based on the Free-Decay magnetic modes, i.e. the well-known solutions of the magnetic induction equation without advection term. In the absence of background magnetic field, u=0 and b is exactly a Free-Decay mode, i.e. the solution is purely decaying in time in the rotating frame. However, as soon as a background field B0 is considered, u and b becomes coupled through both the Lorentz force in the motion equation of the flow, and the advection term in the induction equation. A dramatic consequence of this coupling is that the solutions become propagative with an angular frequency ω quadratic in B0 in the rotating frame.

The properties of these Quasi-Free-Decay magnetic modes, a particular case of the more general Magneto-Coriolis waves, are investigated and cataloged. In particular, these modes can be retrograde or prograde depending on their equatorial symmetry and whether the background magnetic field is poloidal or toroidal. It is also emphasized that the magnetic component of these modes is not a consequence of the underlying flow through the advection term in the induction equation. On the contrary, the associated flow results from the Lorentz forcing in the Navier-Stokes equation. In a second step, the flow acts on the magnetic component through a perturbative feedback via the advection term, imposing at the same time the propagative behaviour. Consequences of this two-step mechanism are discussed in relation to the dynamics of the Earth's outer core.