Driven inertial waves in spherical Couette flow

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Dynamo action in the cores of planets and stars gives rise to their magnetic fields. We explore spherical Couette flows in liquid sodium as a laboratory model of the Earth's core. Below, we image various spatiotemporal magnetic-field modes present in spherical Couette flows. Our apparatus is comprised of two independently driven rotating spheres, radii 20 and 60 cm, with sodium filling the gap between them (Fig. 1). We apply a $B_0=50$ G axial magnetic field from external magnets and image the resulting induced magnetic field. As the Lundquist number $S=(B_0 l)^*(\eta^2\rho\mu_0)^{-1/2}$ (where l is a characteristic length scale, η is the magnetic diffusivity, and ρ is the density) is small ($S=0.7$), the magnetic field is a passive probe of the internal flows. Data from an array of 21 Hall probes along a meridian (M1…M21), plus four more distributed along the equator (E1…E4), are used to characterize the induced magnetic field exiting the outer sphere. We have projected the resulting data onto a basis of spherical harmonics and used that projection to produce the magnetic-field images shown (Fig. 2). Patterns of Coriolis-restored inertial waves are present when the Ekman number, $E=\nu/(2\Omega_o l^2)$ (where ν is the kinematic viscosity and Ω_o is the angular frequency of the outer sphere), is small, and they depend on the rotation rate ratio of the inner and outer spheres Ω_i/Ω_o. All data shown here are for fixed $\Omega_o=30$ Hz ($E=1.2\times10^{-8}$). The spectrogram at the left of Fig. 2 shows the frequency content of a time series of a single equatorial probe. These wave modes are likely to occur in the Earth's outer core, but would largely be masked from view by the mantle.

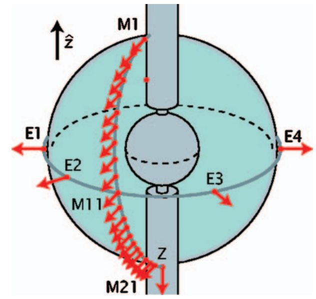

FIG. 1. Experimental setup.

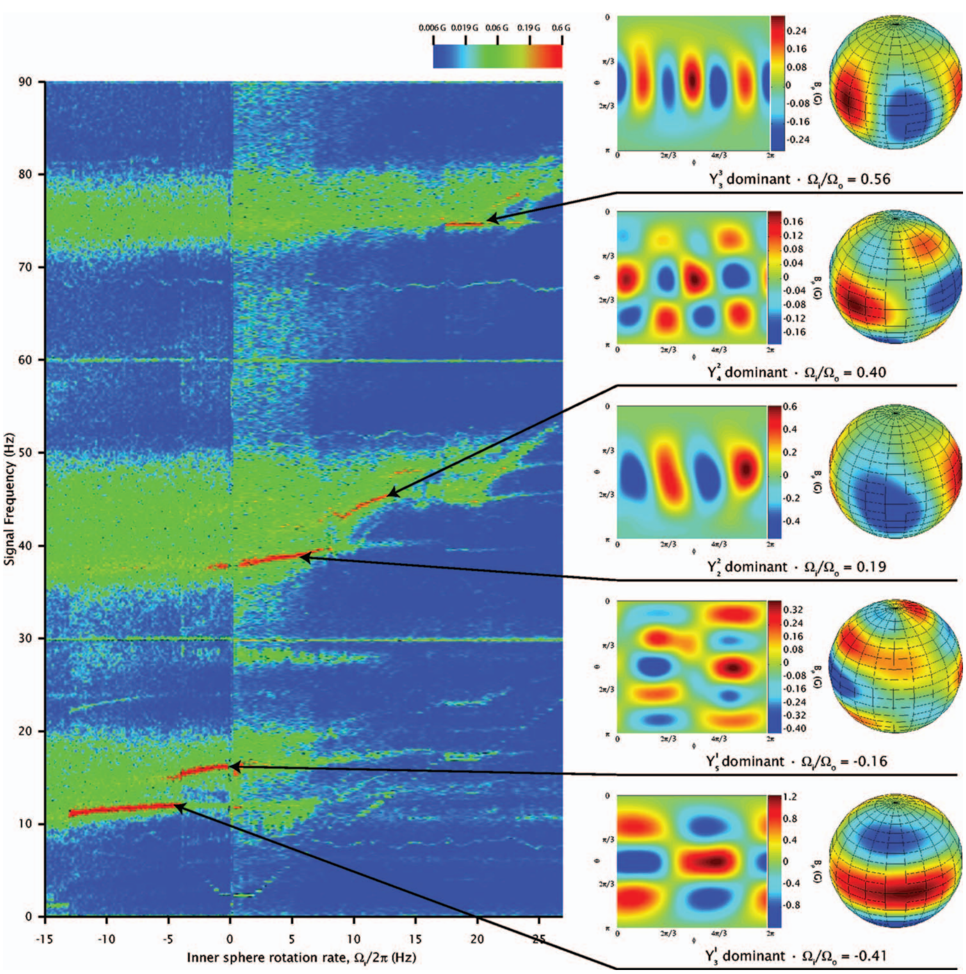

FIG. 2. Spectrogram and magnetic modes.

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