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Fast (non-)diffusive Quasi-Geostrophic Magneto-Coriolis Modes in the Earth's core

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Fast changes of Earth's magnetic field could be explained by inviscid and diffusion-less quasi-geostrophic (QG) Magneto-Coriolis modes. We present a hybrid QG model with columnar flows and three-dimensional magnetic fields and find modes with periods of a few years at parameters relevant to Earth's core. These fast Magneto-Coriolis modes show strong focusing of their kinetic and magnetic energy in the equatorial region, while maintaining a relatively large spatial structure along the azimuthal direction. Their properties agree with some of the observations and inferred core flows. We find additionally, in contrast to what has been assumed previously, that these modes are not affected significantly by magnetic diffusion. The model opens a new way of inverting geomagnetic observations to the flow and magnetic field deep within the Earth's outer core.