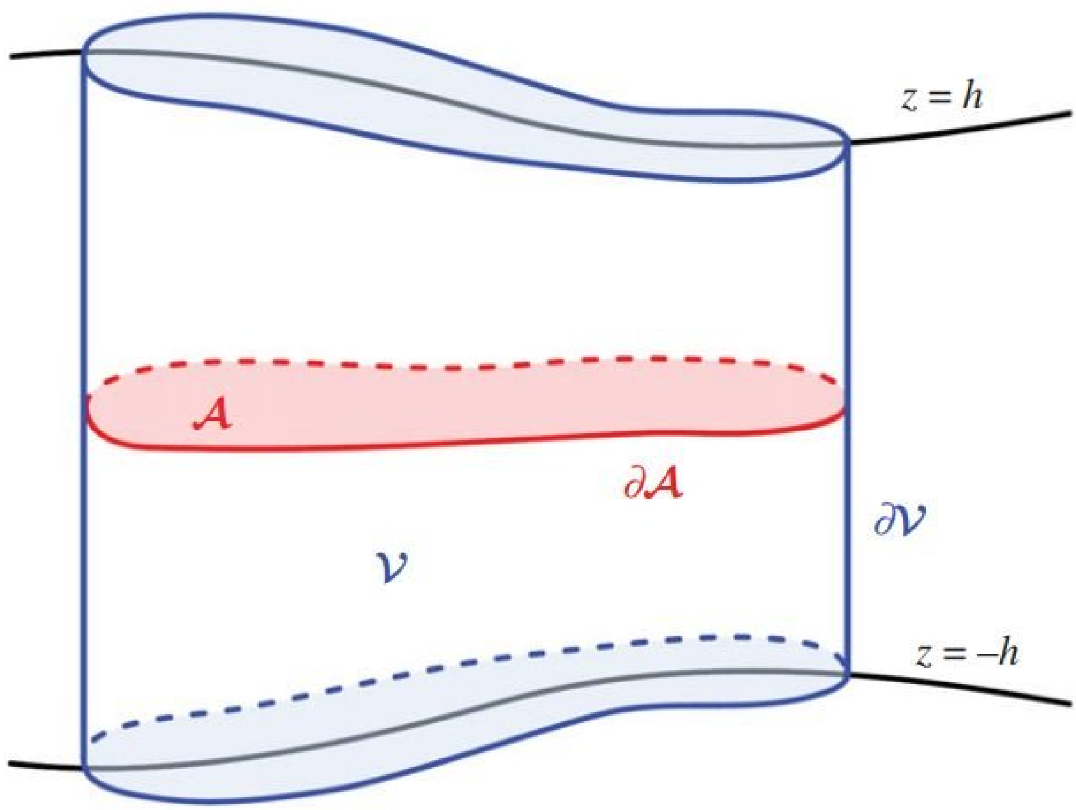
Are Rossby waves to blame for Earth's magnetic field drifting westward?

May 16 2018, by Bob Yirka



Schematic of the control volume considered when deriving the governing equation for a QG flow. Credit: *Proceedings of the Royal Society A: Mathematical, Physical and Engineering Science* (2018). DOI: 10.1098/rspa.2018.0119

A doctoral student at the University of Cambridge has come up with a possible explanation for the westward drift of the Earth's magnetic field. In his paper published in *Proceedings of the Royal Society A*, O.P. Bardsley suggests it may be due to Rossby waves generated in the Earth's core.

Humans first became aware of the Earth's magnetic field over 400 years ago, and since that time, have been taking measurements of it. As time passed, it became clear that the field was moving in a westerly direction—and nobody knew why. The actual reason is still not known—Bardsley is proposing a new idea: Somehow, Rossby waves in the Earth's outer core cause the magnetic drift.

Prior efforts to explain the westward drift have also involved the outer core—one theory suggests that it has a gyre, similar in some respects to the jet stream. If so, it could be dragging the magnetic field as it moves slowly westward. The problem with that theory, Bardsley notes, is that no one has ever found any other evidence of a gyre in the outer core. He suggests Rossby waves make more sense.

Rossby waves are slow and arise when fluids rotate. Because they are generated by most planets, some scientists have taken to calling them planetary waves. Rossby waves on Earth are generated in several places—in the oceans, the atmosphere and the outer core. It is those generated by the fluid in the outer core that Bardsley suggests might be pushing the magnetic field. But there is one major problem: The outer core generates wave crests that move east, not west. Bardsley suggests that this may not be a problem after all—he notes that some ocean waves with crests moving in one direction expend energy in the opposite direction. If that is the case with outer core Rossby waves, he suggests, they could be pushing the magnetic field. He notes that current technology only allows for measuring the energy of the magnetic field in a general sense, not the small details. Much more research is required, he acknowledges, before his theory can be tested, much less proven right or wrong.

More information: O. P. Bardsley. Could hydrodynamic Rossby waves explain the westward drift?, *Proceedings of the Royal Society A: Mathematical, Physical and Engineering Science* (2018). DOI: 10.1098/rspa.2018.0119

Abstract

A novel theory for the origin of the westward drift of the Earth's magnetic field is proposed, based upon the propagation of hydrodynamic Rossby waves in the liquid outer core. These waves have the obscure property that their crests always progress eastwards—but, for a certain subset, energy can nevertheless be transmitted westwards. In fact, this subset corresponds to sheet-like flow structures, extended in both the axial and radial directions, which are likely to be preferentially excited by convective upwellings in the Earth's rapidly rotating outer core. To enable their analysis, the quasi-geostrophic (QG) approximation is employed, which assumes horizontal motions to be independent of distance along the rotation axis, yet accounts for variations in the container height (i.e. the slope of the core–mantle boundary). By projecting the momentum equation onto flows of a QG form, a general equation governing their evolution is derived, which is then adapted for the treatment of two initial value problems—in both Cartesian and spherical geometries—which demonstrate the preference for westward energy propagation by the waves in question. The merits of this mechanism as an explanation for westward drift are discussed.

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