A symmetry-breaking self-regulating dynamo generating Mercury’s anomalous magnetic field

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The discovery of Mercury’s unusually axisymmetric, anomalously axially offset dipolar magnetic field shows a new regime of planetary magnetic fields. The cause of the offset dipole remains to be resolved, although some exotic models have been proposed. Since the magnetic fields of the terrestrial planets are generated by fluid motions in the liquid iron core through dynamo action, which is inevitably linked to the structure and evolution of planetary interiors, untangling why Mercury has such an anomalous field is not only crucial for understanding the internal dynamics, evolution history and origin of the planet, but also essential for establishing the general theory of planetary magnetic fields by extending our knowledge to small bodies in our solar system such as Ganymede, Moon and asteroids. In this study, we use numerical dynamo models. Convection is driven as thermo-compositional convection. A thermally stably stratified layer is imposed in the outer part of the core. It is found that the magnetic fields similar in morphology as well as strength to that of Mercury are reproduced. Also, the dynamo-generated magnetic fields act on the flow to induce interaction between equatorially symmetric and antisymmetric components, and resultantly to yield north-south asymmetric helicity. Additional runs demonstrate that the offset dipolar field cannot be maintained without the magnetic self-regulating effect. Thus, it is concluded that the symmetry breaking self-regulating effect causes the flow to generate and maintain the Mercury-like offset dipolar field.

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