

Was the geodynamo quadrupolar in the past?

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The geomagnetic field has been maintained by dynamo action for billions of years. This fact implies that dynamo action occurs even in the absence of the solid inner core at the early stage of the geodynamo, although the age of the inner core is still in debate. As summarized in the following, whether the inner core exists or not causes some differences in the core. First, compositional convection does not occur before inner core solidification, and then, convection is driven by thermal buoyancy alone due to secular cooling of the core. Second, the tangent cylinder, an imaginary co-axial cylinder in touch with the inner core at the equator, is not geometrically defined in the absence of the inner core. Third, the inner core stabilizes magnetic polarity by introducing an independent diffusive time scale due to its finite electrical conductivity. Especially, the last one suggests that the geomagnetic field more frequently reversed its polarity in the ancient past. In order to obtain insights into the subject, numerical dynamo simulation is useful. Hence, we examine by numerical dynamo modeling how the absence of the inner core affects dynamo action. Most simulations are conducted at the Ekman number of 10^{-5} with other parameters varied. It is found that the magnetic field shows quadrupolar configuration, which periodically changes its polarity, in the explored parameter space. The present results might suggest that the geomagnetic field was quadrupolar and reverses more often before solidification of significantly large inner core.