KINEMATIC DYNAMOS REVISITED

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The self-exciting dynamo mechanism is central to understanding the behaviour of Earth's and other astroplanetary magnetic fields. The first numerically convincing laminar kinematic dynamos in spherical conductors were reported by various authors between 1971 and 1975. All these dynamos were based on multi-cellular flows of some complexity. However, early in this period four models based on simple single or double cell axisymmetric flows were studied without yielding self-exciting dynamos (Fraser 1972). We have reinvestigated these models and found that for appropriate choices of parameters, they do support self-sustaining dynamos. We have also found numerous other similar simple flows that support self-exciting dynamos. For most models a straightforward intuitive search of parameter space yielded growing magnetic modes. Some models were more difficult, requiring systematic wide-ranging searches, allowing for high frequency magnetic oscillations. Other models only yielded growing magnetic modes under asymptotic analysis.

The resulting magnetic field parities are dipole, quadrupole, or neither. Some fields are steady; others are rapid rotators that are steady in some rotating reference frame. These many positive results add weight to the occasionally made conjecture that all but special isolated flows (e.g. purely toroidal) can support dynamo action in some region of parameter space. However, we give several examples, only marginally different from our successful flows, where no dynamo action has been found, despite extensive searching of parameter space in both finite and asymptotic domains.

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