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A super-rotating dynamo for Saturn

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Self-sustaining magnetic dynamos are commonplace among planets, stars, and galaxies. Most planetary dynamos are thought to be driven by convection, and numerical models have shown that convection-driven dynamos can account for much of the observed complexity in planetary magnetism, including nonaxisymmetric fields, inclined dipole axes, and polarity reversals. Saturn's dynamo appears to be exceptional, however, and requires additional explanation. Both Voyager and Casinni spacecraft measurements have shown the Kronian magnetic field is highly symmetric and relatively simple. Here we present a new class of numerical dynamos driven by super-rotation that produce simple nearly-axisymmetric external magnetic fields. We solve for flow and dynamo action of a conducting fluid that fills the cavity between two diffentially rotating spheres. When the differential rotation exeeds a critical value the shear flow becomes unstable. These instabilities can in turn drive a dynamo. Applied to Saturn, such dynamos offer constraints on the rotation rate and the inner and outer radius of its electrically conducting liquid core. And unlike convection, very strong super-rotation is easy to produce in laboratory settings, making it a good candidate for experimental dynamos in liquid metals.