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Does Saturn have a solid core? Evidence from its intrinsic magnetic field

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Study of Cassini magnetometer measurements (Cao et al., 2011, 2012)
- extreme axisymmetry: dipole tilt < 0.06 deg
- no detectable secular variation
- high degree moments (n>3) are identified for the first time
- distinct magnetic field geometries at the dynamo surfaces:
  - polar field maxima (Saturn) VS. polar field minima (Earth)

What Causes the Polar Field Minima at the Earth
- Anticyclonic polar vortex and upwelling flow inside the tangent cylinder (TC) expel magnetic flux away from the polar region

Cassini 5
Coeff. g10 g20 g30 g40 g50 Value [nT]
-80 21191 +/- 24 1586 +/- 7 2374 +/- 47 65 +/- 70 185 +/- 100

CPS9-P16

Saturn’s Intrinsic Magnetic Field: Some Recent Discoveries
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  - distinct magnetic field geometries at the dynamo surfaces:
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Could the Solid Inner Core Size Play a Role?
- The presence of the solid inner core defines the tangent cylinder (TC)
  - TC divides the fluid dynamo region into three parts:
    - in the north TC, in the south TC, and outside the TC
  - Fluid in the north TC and south TC hardly communicate, could lead to equatorial asymmetry
  - Different flows, such as a thermal wind could develop inside the TC

Inner Core Size Effects: Magnetic Field
- With uniform outer boundary heat flux, the size of the polar field minimum is controlled by the relative size of the inner core

Boundary Heat Flow Effects: Magnetic Field
- With χ = 0.20, the magnetic fluxes get more and more concentrated towards the rotation poles as the amplitude of Y20 heat anomaly gets increased (The equatorial region gets emptier in magnetic fluxes)

Same Heat Anomaly with Different Inner Core Sizes
- The effects of a moderate heat anomaly, a=0.23, are mediated by the inner core sizes

The observed magnetic field of Saturn favors a small (<10 Earth Masses) core inside this planet and some Y20 type heat anomaly at the dynamo surface