Lithium Destruction and Magnetic Confinement in the Solar Interior

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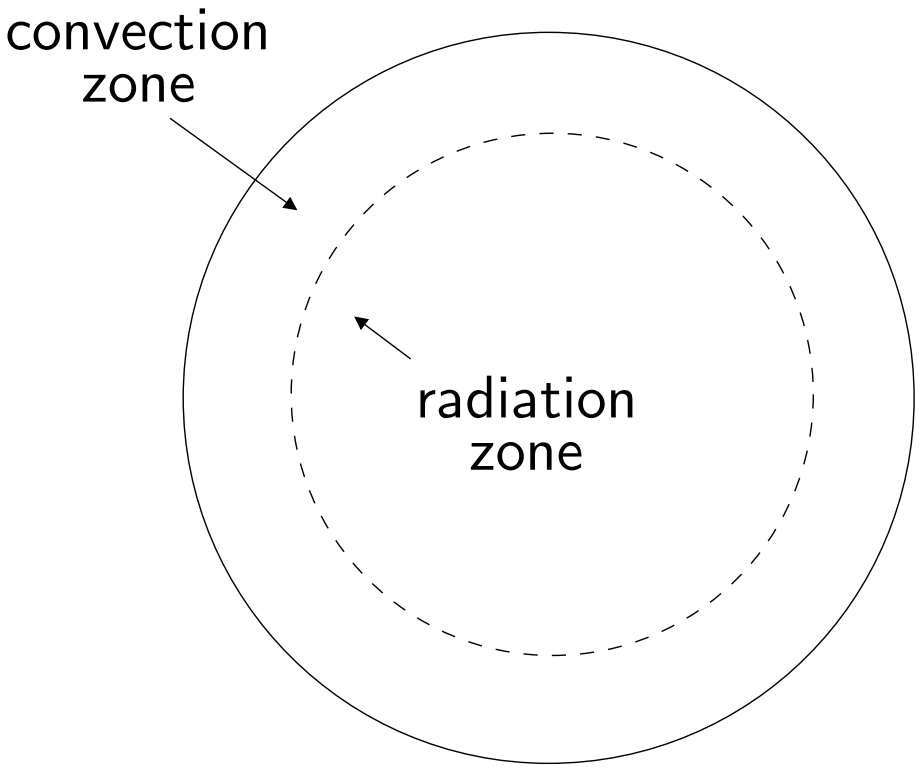
The Sun's internal structure



- Convection zone is well mixed by turbulence
- Radiation zone is stably stratified

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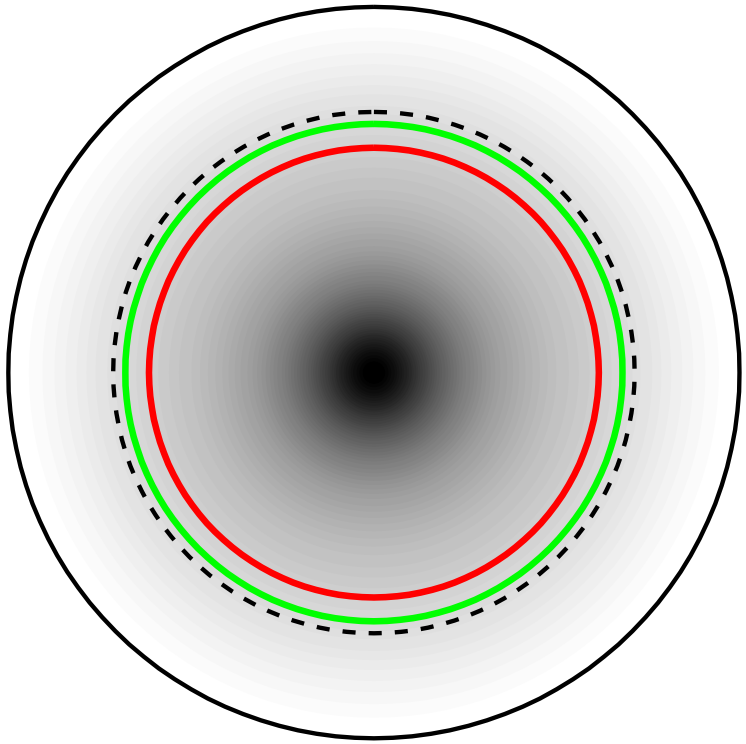

2.5×10^6 K, 3×10^6 K

- Convection zone's lithium depleted by more than 99%
- Convection zone's beryllium not depleted

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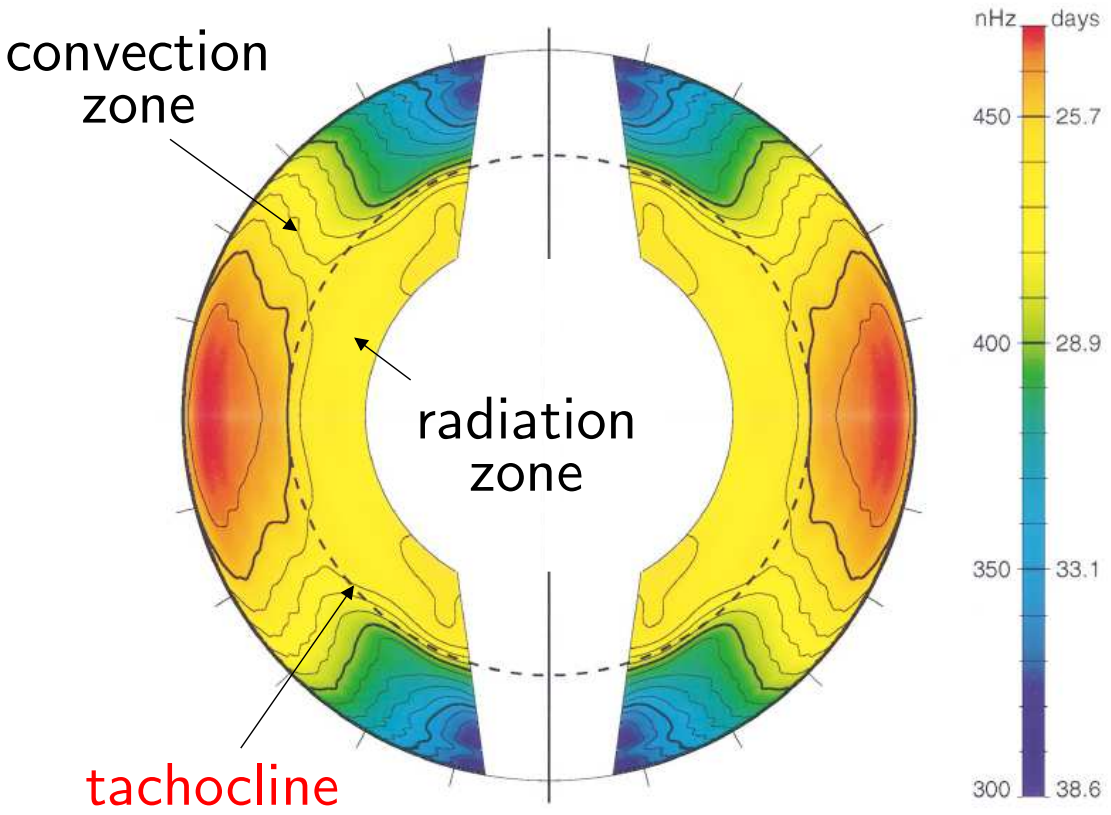


Source: Schou et al. (1998)

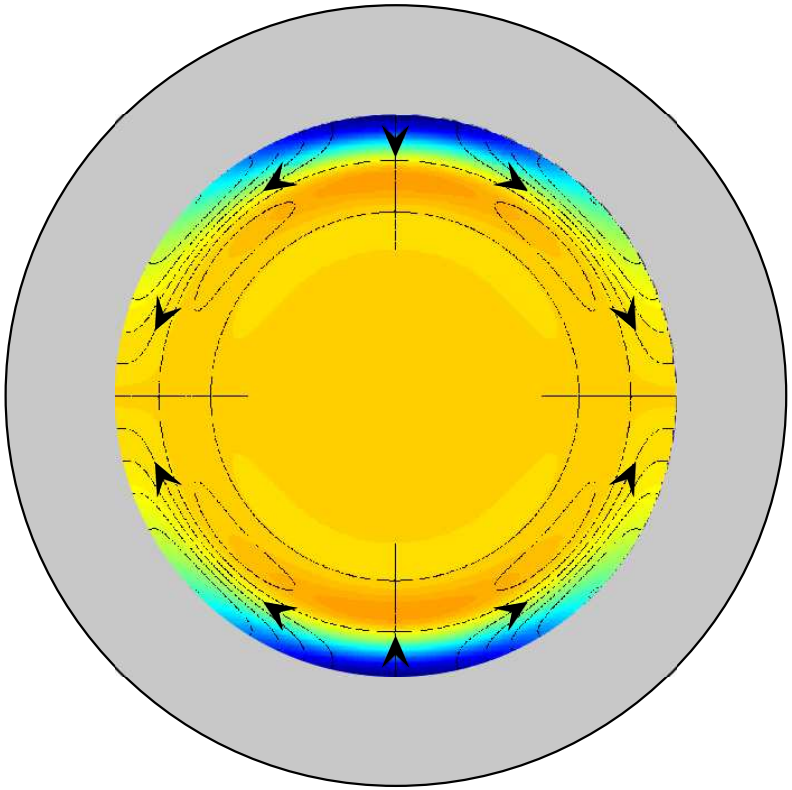
- Convection zone rotates differentially, poles 30% slower than equator
- Radiation zone rotates uniformly with a period of 27 days

Interior "mixing" by meridional circulation

- Convection zone's differential rotation drives meridional flows that burrow into the interior (Spiegel & Zahn, 1992)

- The flows transport lithium, beryllium
  ... and angular momentum

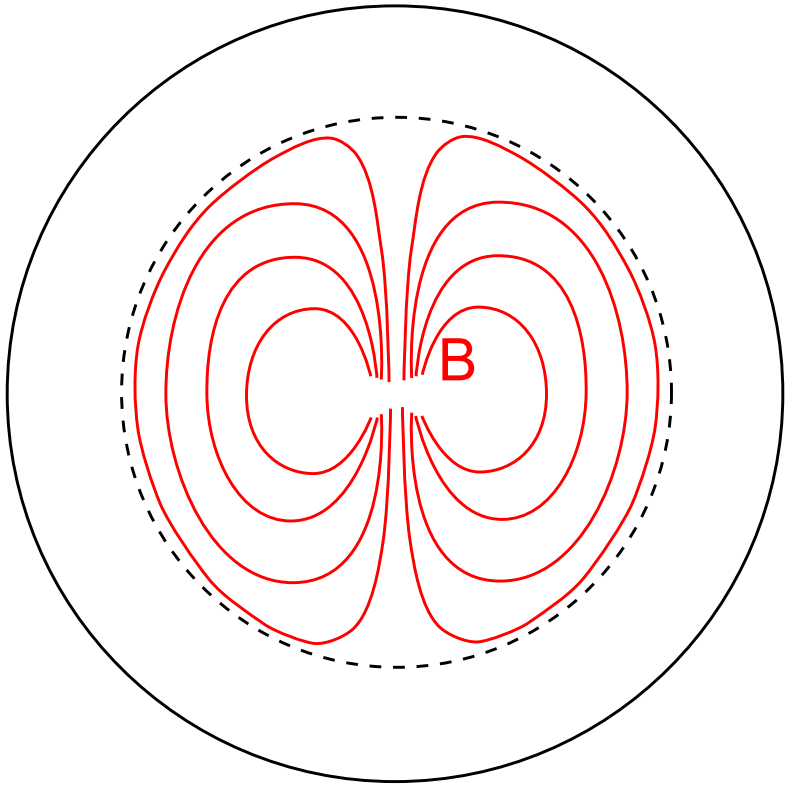
- Polar regions spun down by angular momentum extraction



- Unchecked, the flows would by now have burrowed half-way to the center of the Sun

What stops the burrowing?

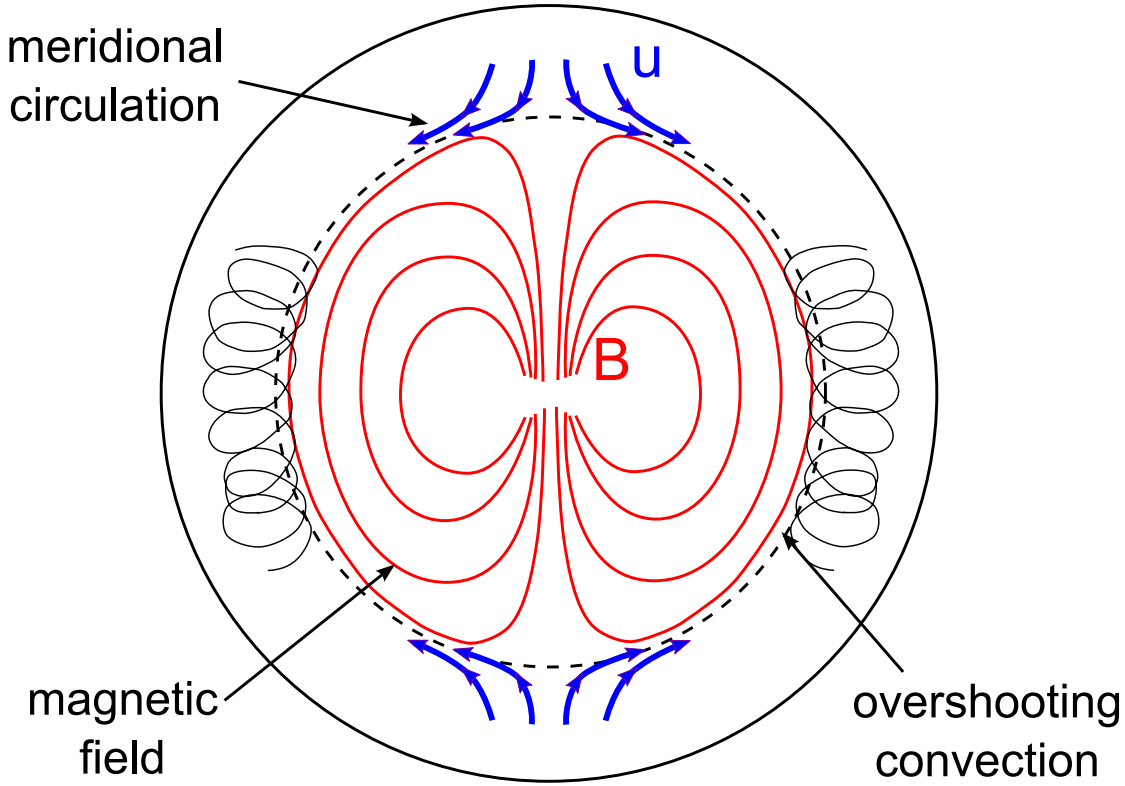
Uniform rotation can be explained by a suitably shaped, global-scale interior magnetic field $\mathbf{B}$ (e.g. Mestel & Weiss, 1987)



- Efficient angular momentum transport along field lines
- Ferraro's Law of Isorotation ($\mathbf{B} \cdot \nabla \Omega = 0$)

Magnetic confinement

The magnetic field is confined in high latitudes by meridional flows (Gough & McIntyre, 1998)



... and in low latitudes by convective "magnetic flux pumping" (e.g. Tobias et al., 2001; Kitchatinov & Rüdiger, 2008)

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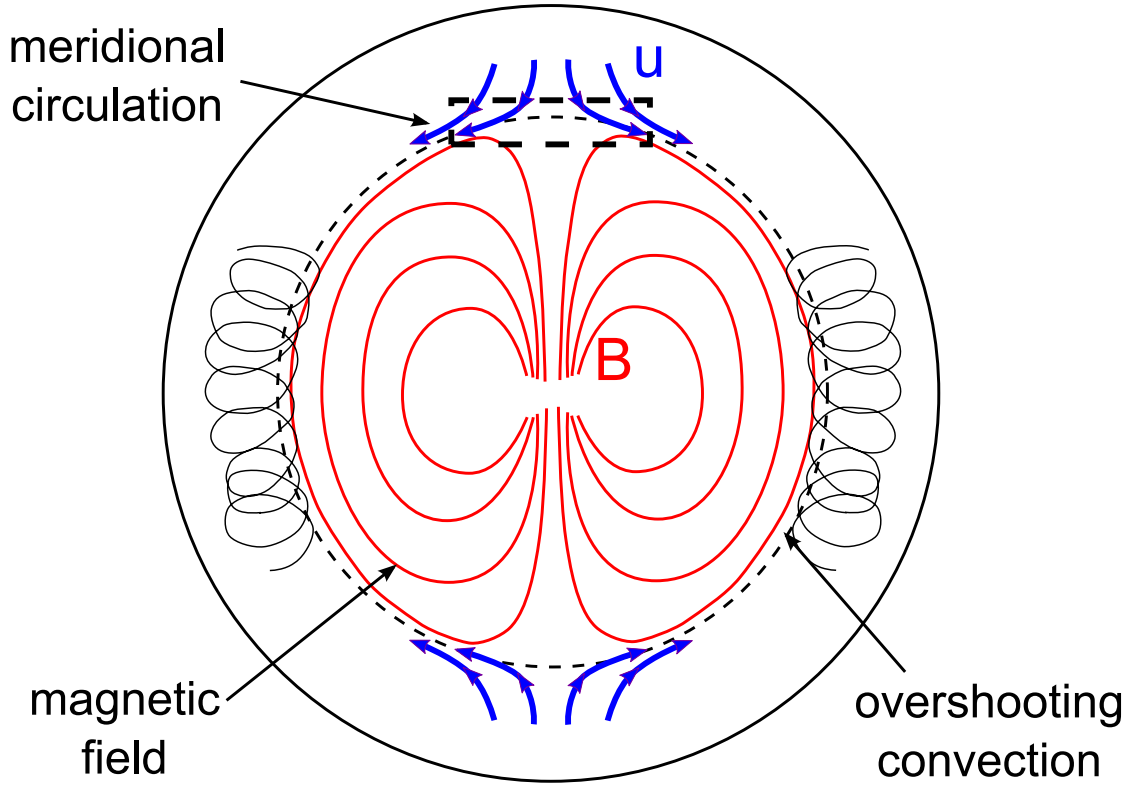

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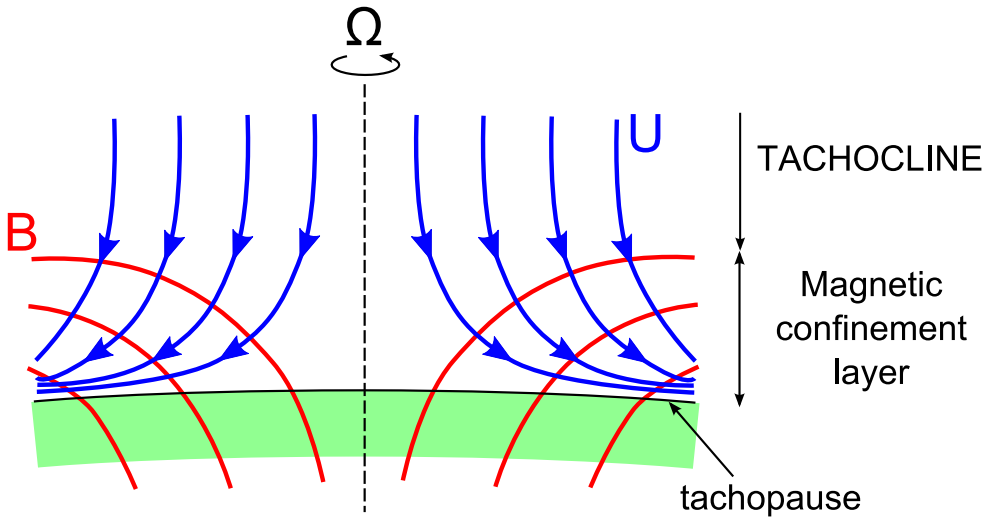
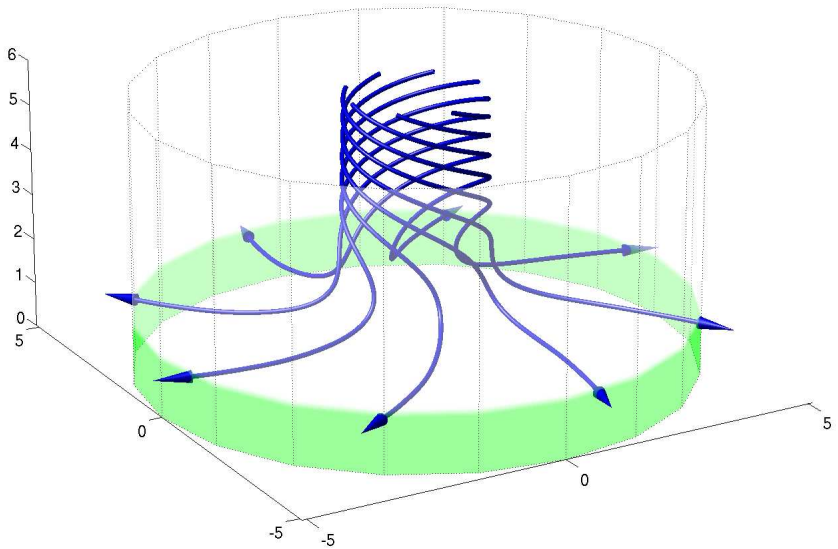
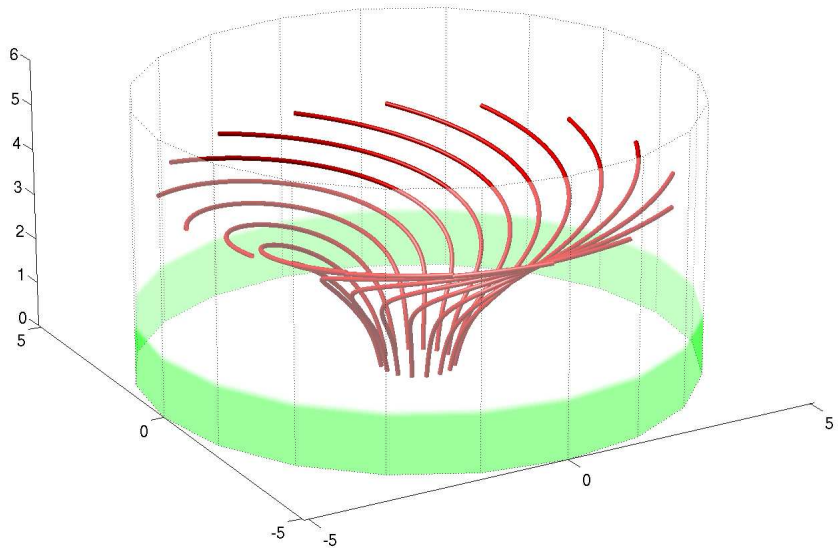
The high-latitude magnetic confinement layer

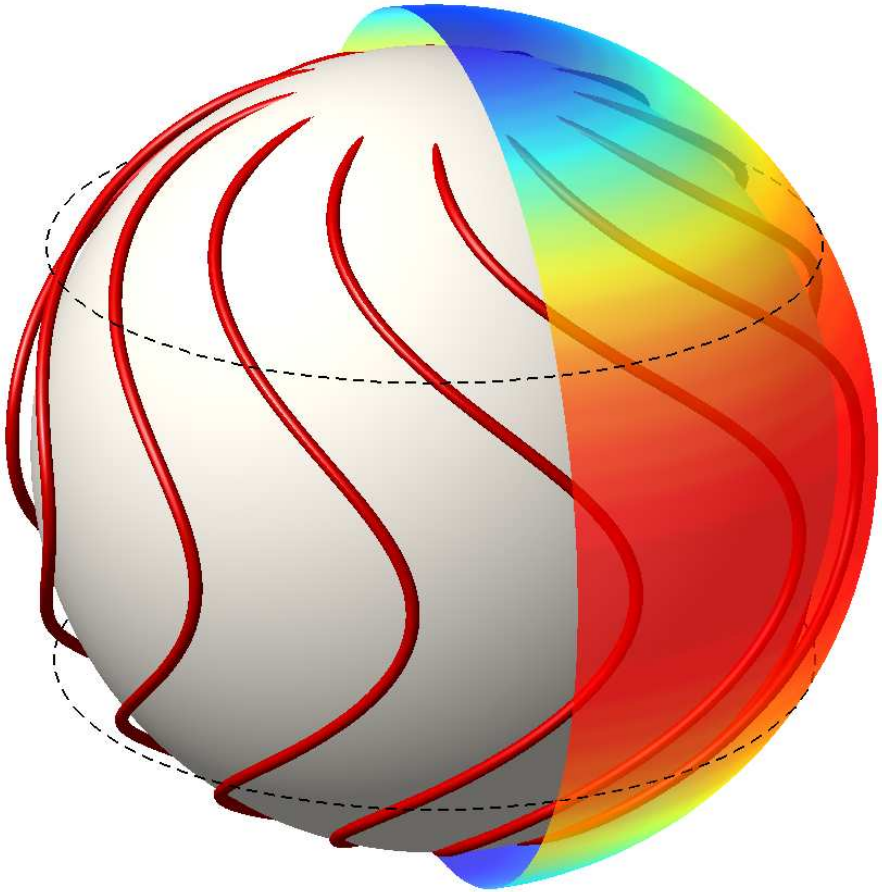






Wood & McIntyre (submitted)

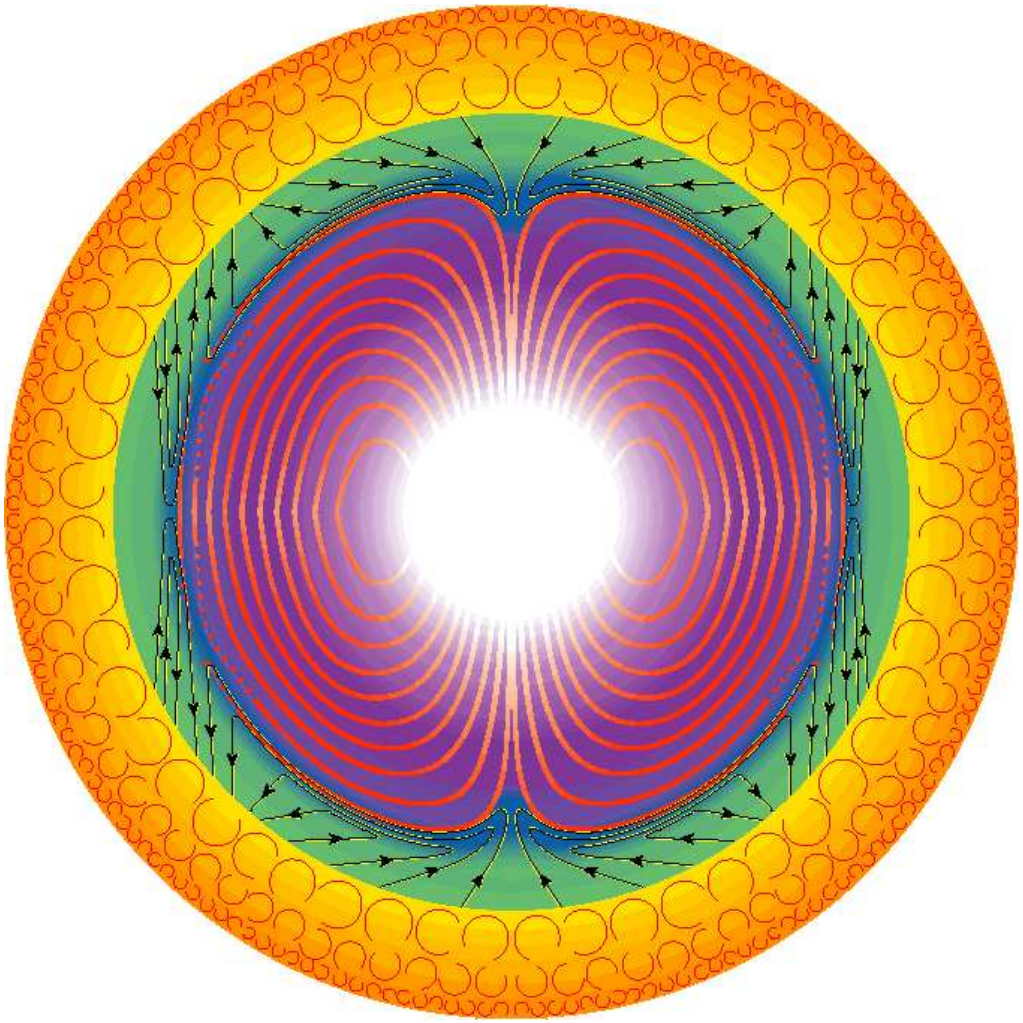
The global picture



- Tachocline's latitudinal shear winds up the magnetic field lines, transmitting a prograde Alfvénic torque to high latitudes

How is lithium destroyed?

Gough & McIntyre (1998) suggested that meridional flows dig "polar pits" at the weak points of the magnetic field



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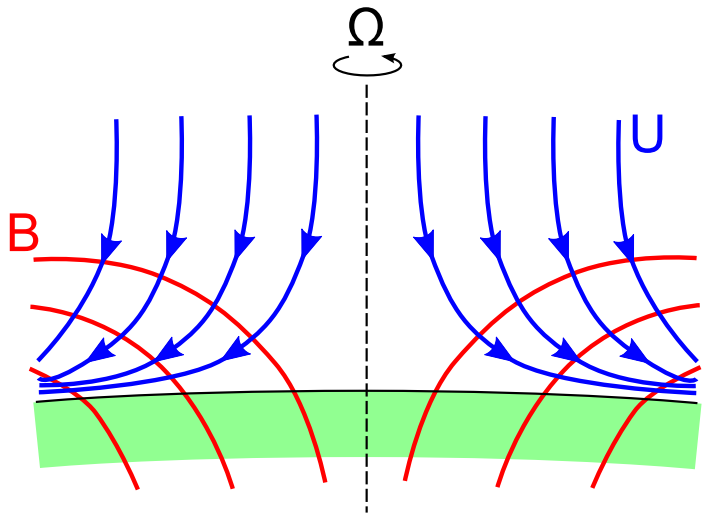

High-latitude confinement layer might form part of a broad polar pit