Solar-Cycle Variations of the Differential Rotation and Tachocline

Rachel Howe, NSO
Synopsis

• The Data
• Global Features
• Temporal Changes
  - Near-surface flows
  - High-latitude changes
  - Tachocline Variations?
• Unanswered questions

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The Data

• **GONG**
  - 65 108-day periods, starting at 36-day intervals, 1995-2001
  - /up to 150

• **MDI**
  - 28 72-day periods, 1996-2002
  - /up to 180 for $p$ modes, 300 for $f$ modes

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Solar Cycle at the Surface

- Magnetic field over Doppler zonal flows
  
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Solar Cycle at the Surface

- Doppler zonal flows over magnetic field

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The Global Rotation Picture

2D rotation profile, based on RLS inversions.

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Subsurface Shear

- Radial near-surface gradient from MDI $f$-modes
- Corbard & Thompson 2002

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Near-surface flows

Zonal flows from MDI f modes

- Courtesy J. Schou

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Near-surface flows

- MDI f-modes, courtesy T. Corbard

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Flows from GONG p-modes

- p-modes reveal flows too, here at 0.99R

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Penetrating flows

- Vorontsov et al 2002, *Science*
- MDI, new inversion technique
- High-latitude changes go deep
- Low-latitude flows to 0.92\(R\)

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Now with 50% more data
Now with 50% more data

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Now with 50% more data
Dynamo models

- Can get different period at base of convection zone – 'spatio-temporal fragmentation'

- Covas et al. 2001
- Observed profile used as input
- Uniform density