Helio- & Jovi-seismology
Doppler (and for the sun magnetic) imaging

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How does a magneto-optical filter work?

Based on the design of Tomczyk, et al., (Solar Physics, 159, 1, 1995.), which was a development of the Cacciani, et al., MOF (Solar Physics, 50, 179, 1979)

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The filter produces two pass-bands (≈50mÅ wide) that can be imaged simultaneously.

Pass-band separation set by magnetic field strength in the cell (≈1.5kG/3kG) and potassium vapour optical depth (controlled by temperature)

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Data from the solar version of the instrument

Intensity [770nm]
Velocity, V

Doppler-Magnetograph images (taken from the roof of the JPL magnetometer lab) using an MOF based instrument

Doppler image is \( \frac{I_R - I_B}{I_R + I_B} \)

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The Jovi-seismology version of the instrument on the Mt Wilson 100” telescope

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Jupiter images from 100” Mt Wilson Telescope

- Raw Jupiter images & resulting ‘Dopplergram’
- Everything worked well, but no detection (yet?)
- Instrument pros and cons
  - Very stable, so good for low-frequency observations
  - Allows simple optical design
  - Not easily tunable
  - Isolates part of the disk – good and bad
  - Complementary to other techniques

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Other potential spectral lines

- Many other solar lines Na 589nm, Ca 422.7, SrII 421.5nm...
- Could use lines in the Methane spectrum, corresponding to different depths in the atmosphere
A Doppler-imager for space use

A schematic of the compact Doppler-magnetograph (CDM) flight design. The total mass of the structure, optical elements and magnet assemblies is approximately 1.5 kg. This version of the instrument has a 2” objective and operates in the potassium 770nm line.
Multi-line Doppler/magnetograph at the South Pole

The MOTH II experiment at the South Pole Jan 2008

5 second magnetograms

Na

K

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Possible future directions for observations

• More photons – bigger/more telescopes or improved instrument design
• Additional spectral lines to cover more of the disk (and provide more photons)
  • Intrinsic vs solar lines
  • Observe from the south pole – continuous measurements over many days – smaller telescopes, but longer observations
• Eventually look from space – need confirmed ground observations first
• Look for g-modes and inertial modes as well as p-modes
  • Maybe inertial modes will have bigger amplitudes
  • Longer periods may be more difficult to detect (single observing site, 1/f system noise)
  • Velocities will be horizontal, so perhaps masked by Jovian weather
• Do other things in addition!
  • As mentioned several times so far – use the same instrumentation to look for other phenomena - Doppler images of Jupiter are potentially a rich source of new information on flows and waves
  • Look at other science targets – astro- and helio-seismology
    • Potential for common instrumentation and analysis techniques
• Don’t be pessimistic!

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