Helio- & Jovi-seismology

Doppler (*and for the sun magnetic*) imaging

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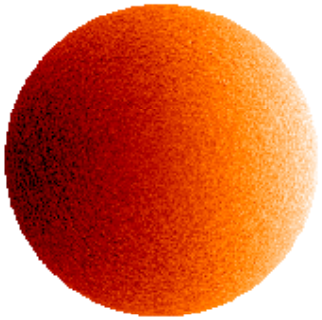
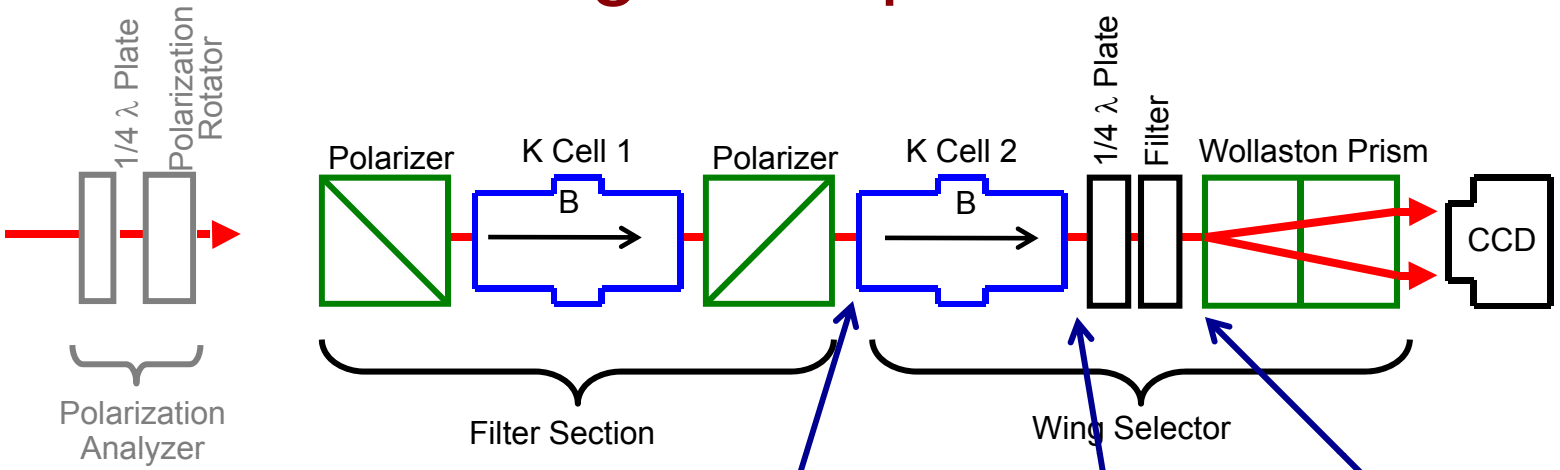
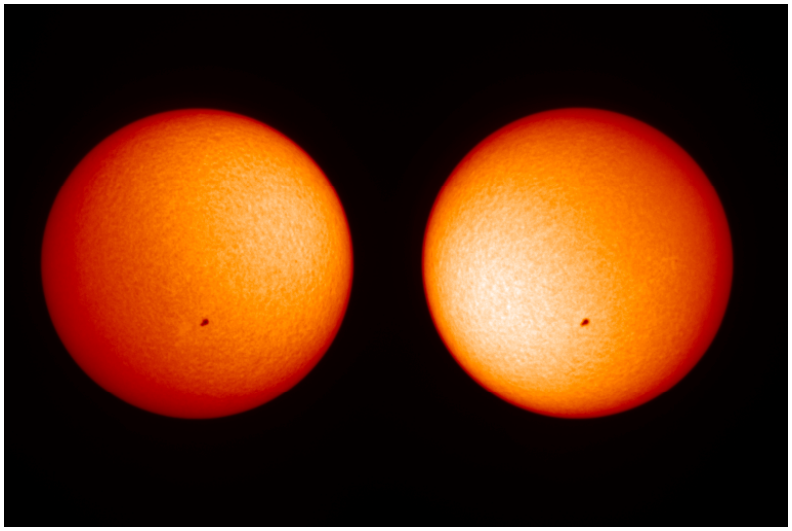


How does a magneto-optical filter work?

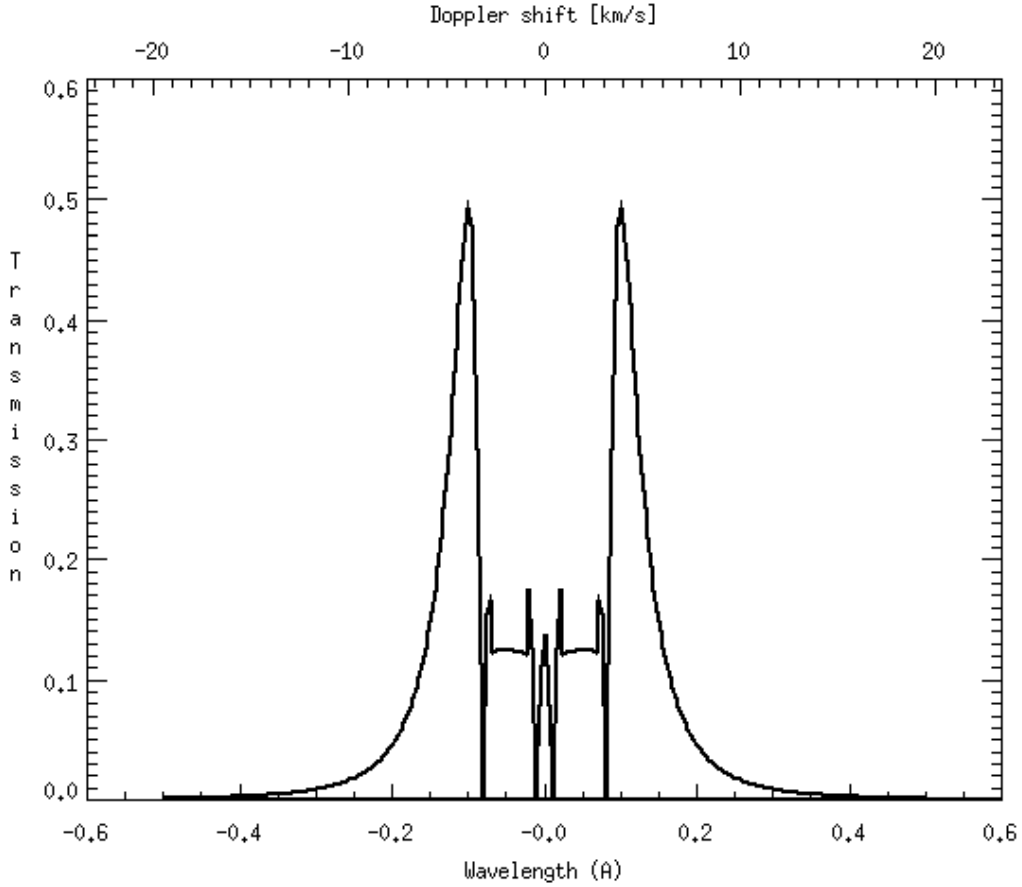




Raw solar images from a Magneto-optical filter

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)

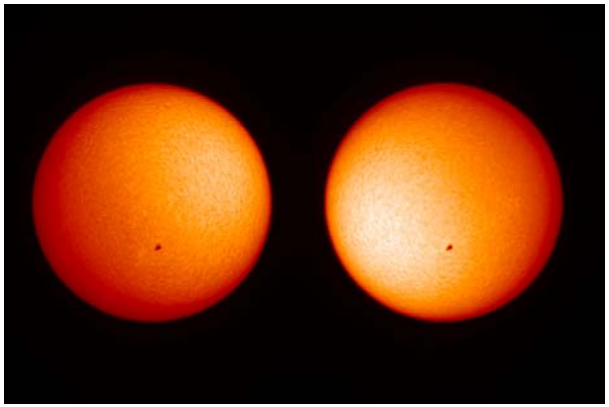
Modeled MOF K 769.9nm transmission



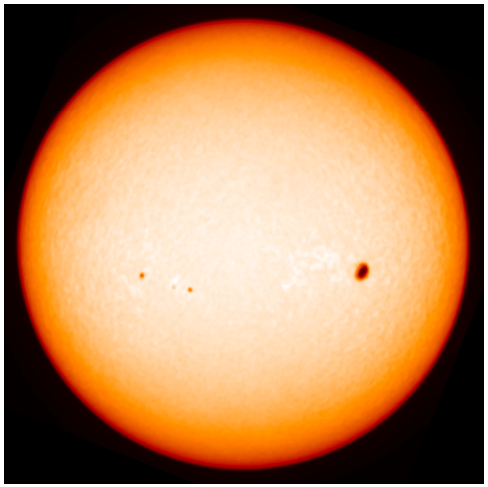
- The filter produces two pass-bands (≈50mÅ wide) that can be imaged simultaneously.
- Pass-band separation set by magnetic field strength in the cell (≈1.5kG/3kG) and potassium vapour optical depth (controlled by temperature)

Data from the solar version of the instrument

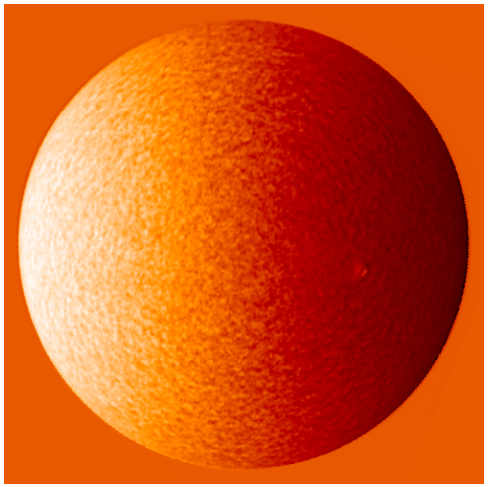
I_R I_B



Intensity [770nm]



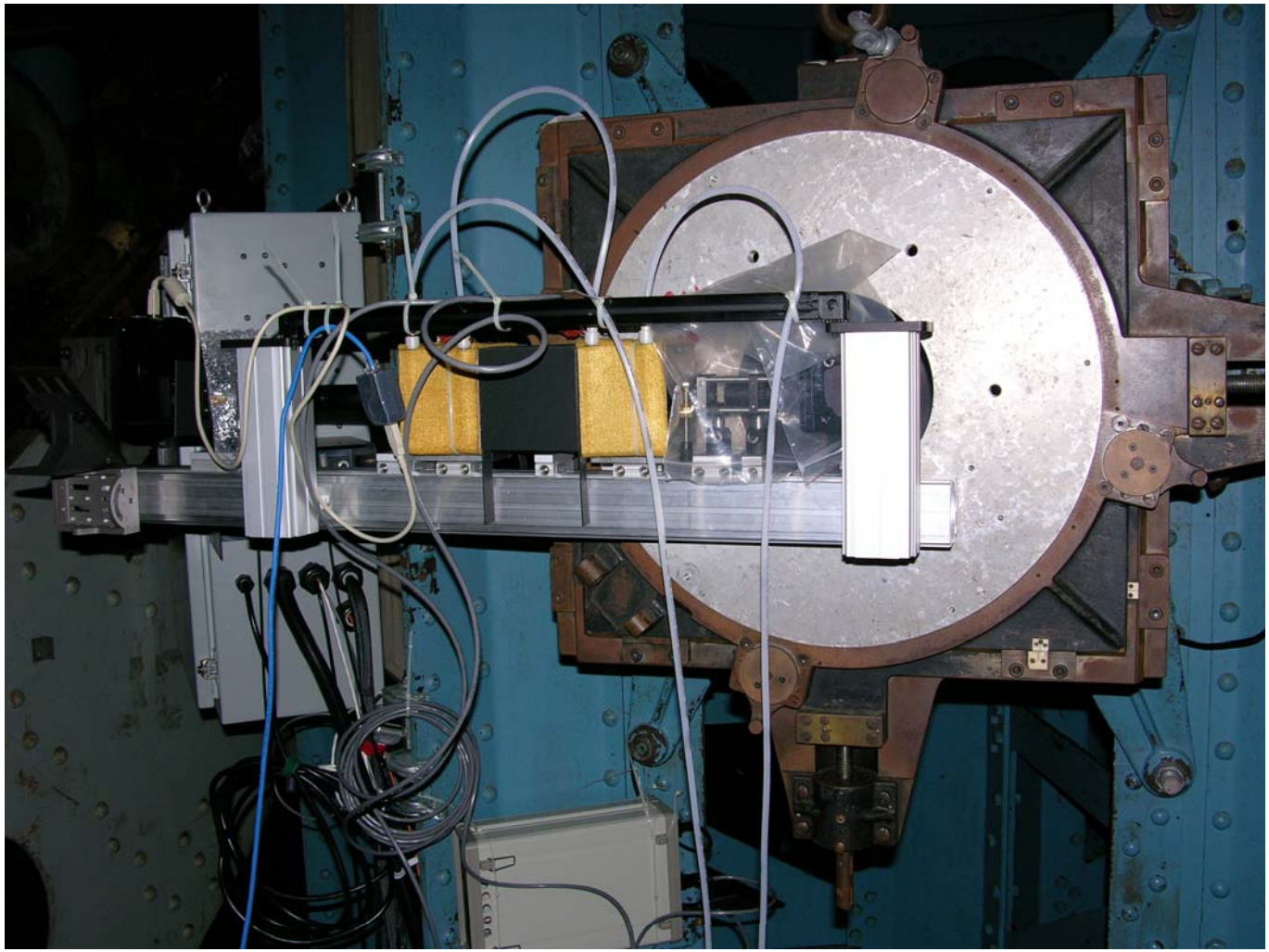
Velocity, V



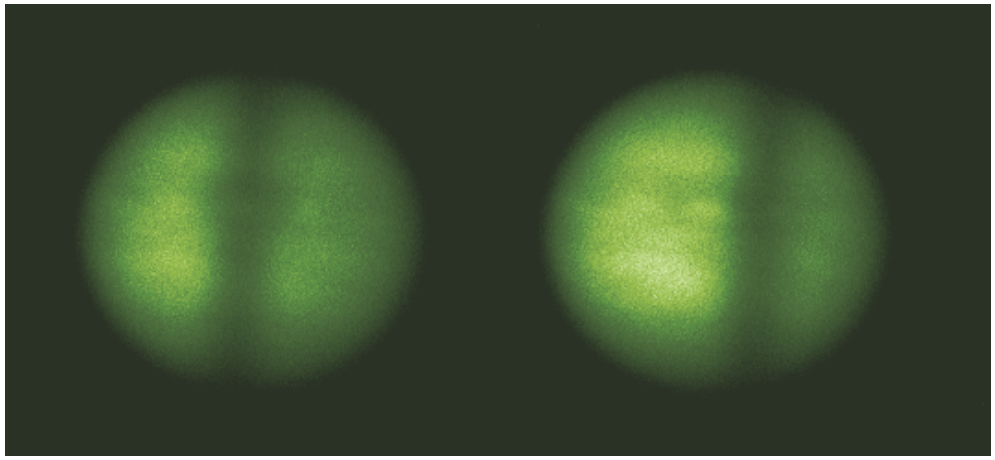
Doppler- Magnetograph images (taken from the roof of the JPL magnetometer lab) using an MOF based instrument

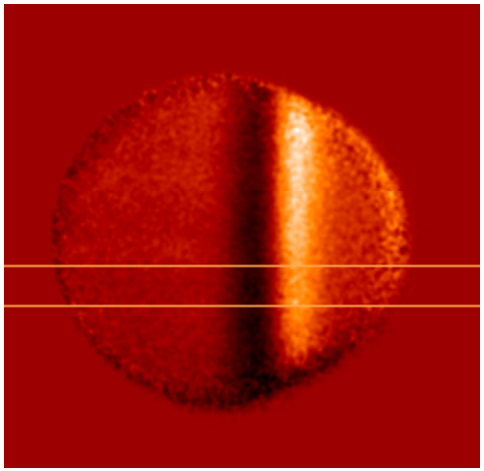
Doppler image is $(I_R-I_B)/(I_R+I_B)$

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



Jupiter images from 100” Mt Wilson Telescope

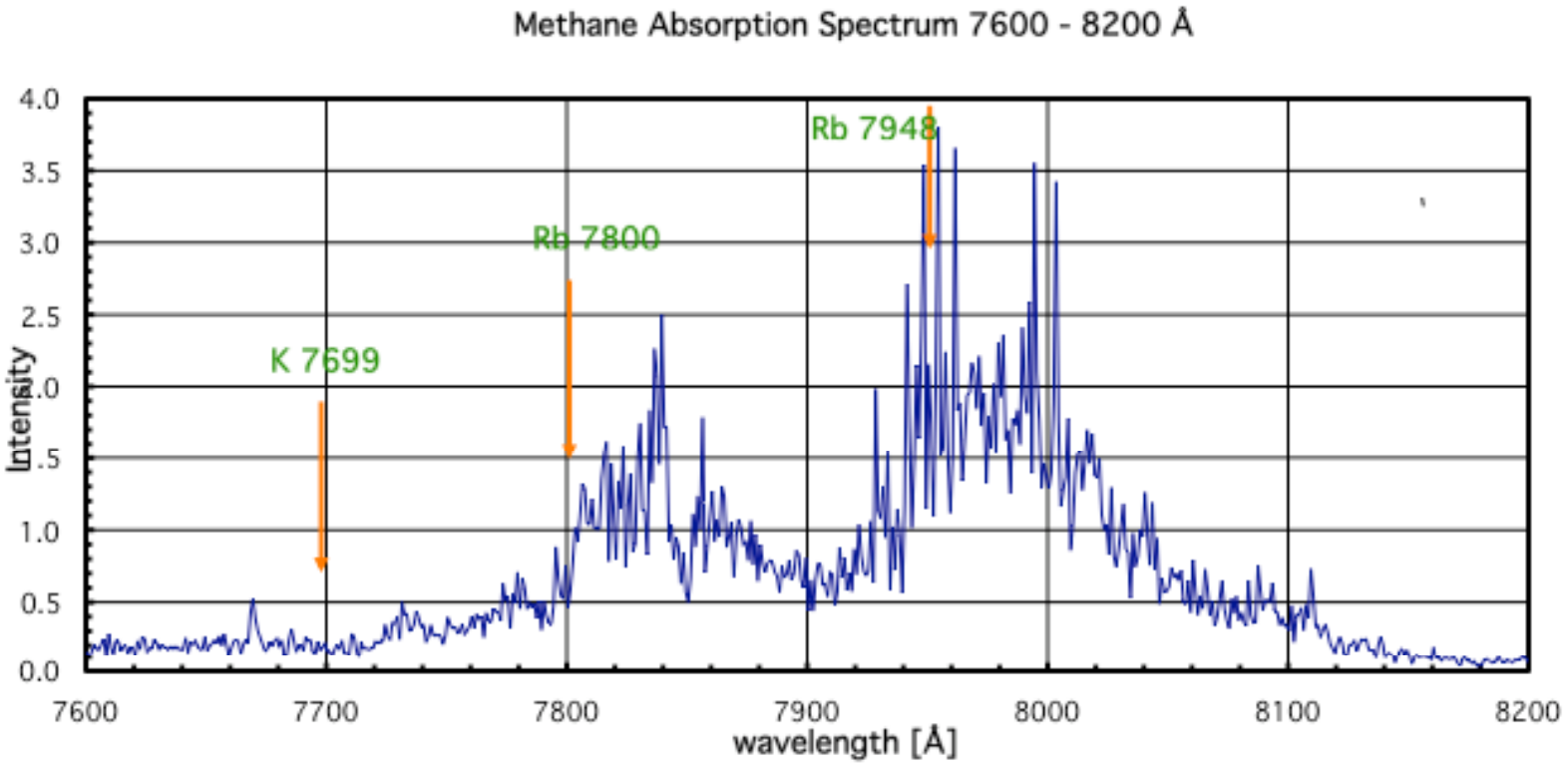




- Raw Jupiter images & resulting ‘Dopplergram’
- Everything worked well, but no detection (yet?)
- Instrument pros and cons
  - Very stable, so good for low-frequency observations
  - Allows simple optical design
  - Not easily tunable
  - Isolates part of the disk – good and bad
  - Complementary to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

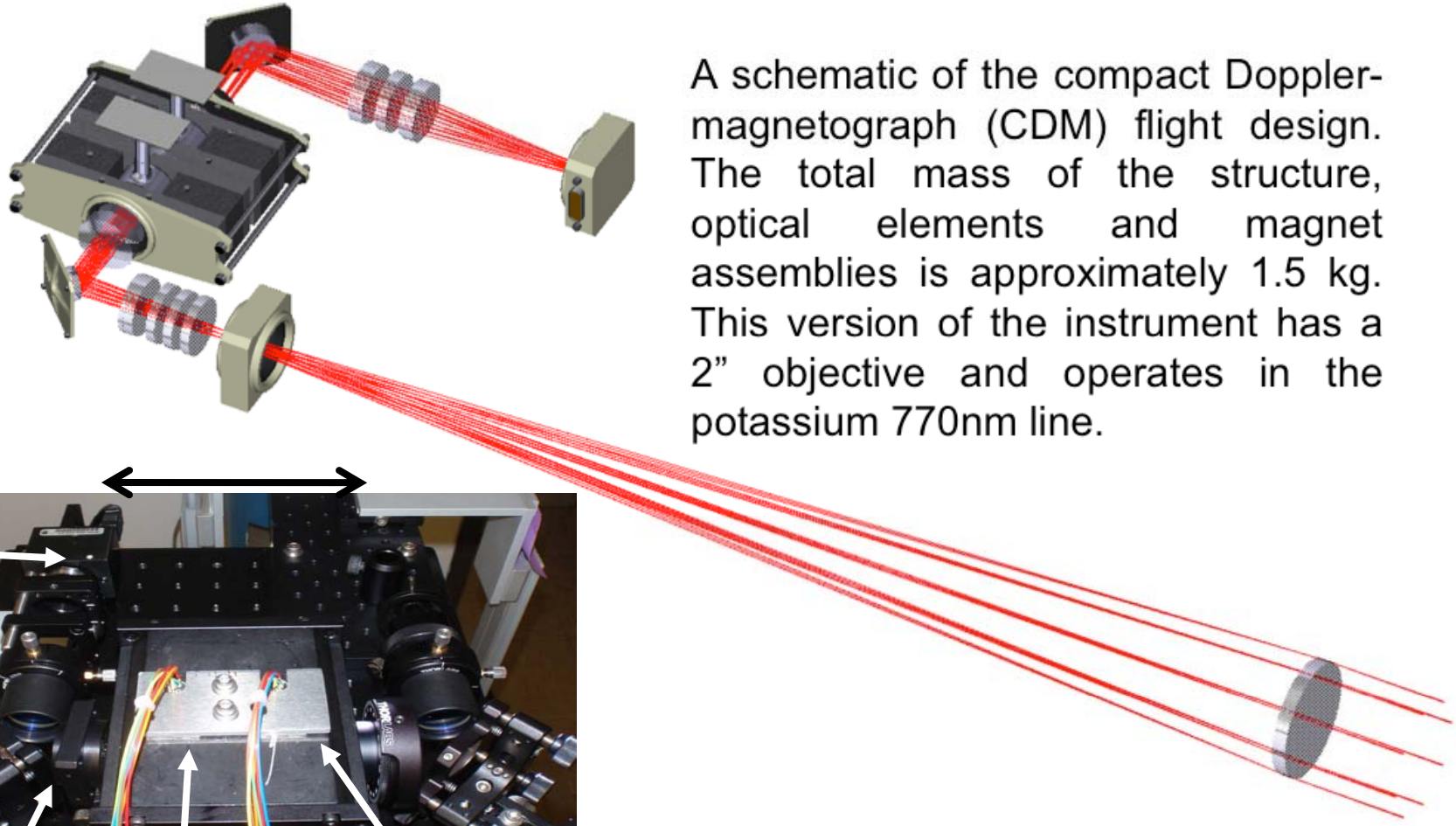
Other potential spectral lines

- 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



KISS, Murphy March 2010

A Doppler-imager for space use



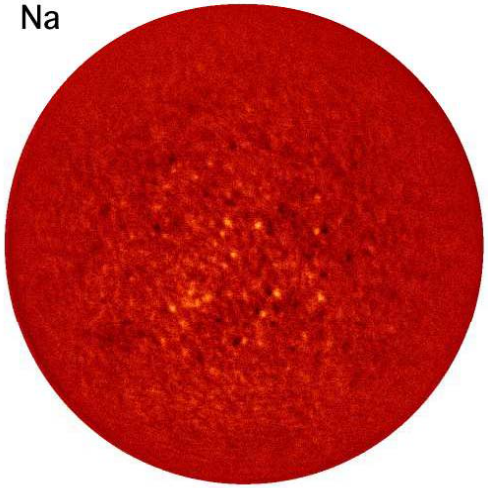
A schematic of the compact Doppler-magnetograph (CDM) flight design. The total mass of the structure, optical elements and magnet assemblies is approximately 1.5 kg. This version of the instrument has a 2" objective and operates in the potassium 770nm line.

Multi-line Doppler/magnetograph at the South Pole

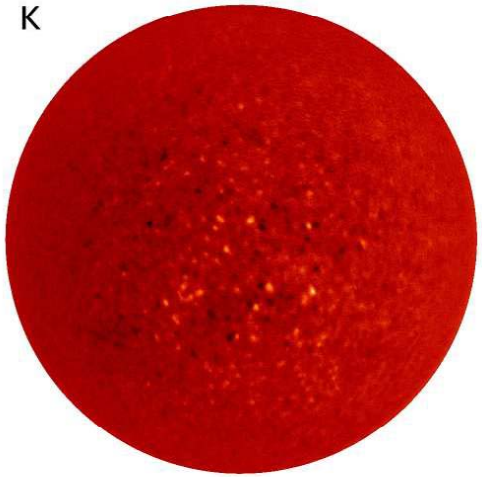
The MOTH II experiment at the South Pole Jan 2008

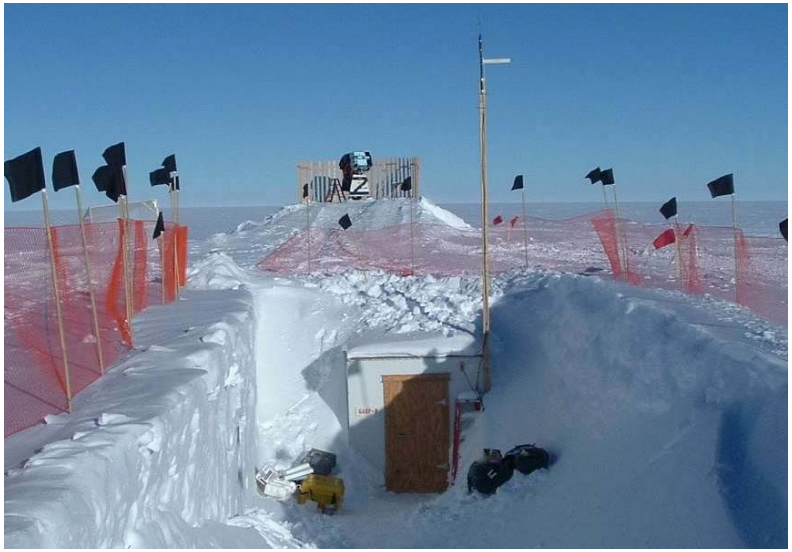
5 second magnetograms

Na



K





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!