Observables, etc.

Jesper Schou

- Overview
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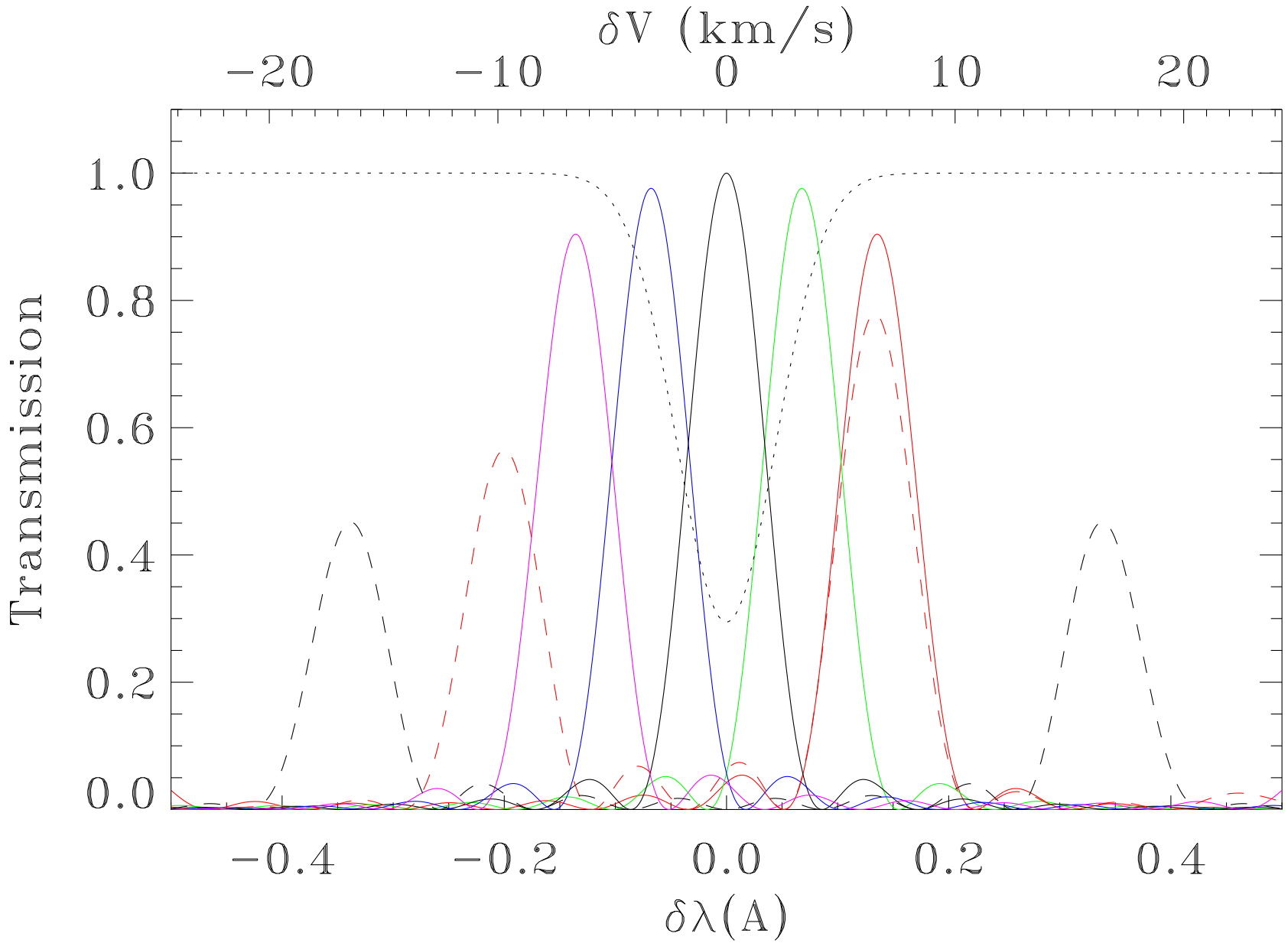
Overview

- Observables
  - -Dopplergrams
  - -LOS magnetograms
  - -Vector magnetograms
  - -Intensity images
  - -Etc.
- Observables made from filtergrams
  - -Ground processing only
  - -Allows for better calibration
  - -Allows for reprocessing, if needed
  - -Low complexity
  - -High data rate

Observing Scheme

- Repeat same sequence of filtergrams (framelist) during normal operations
- Filtergram properties
  - -Wavelength
  - -Polarization state
  - -Camera
  - -Observing mode
  - -Exposure time
  - -...


δV (km/s)
−20
−10
0
10
20
1.0
0.8
0.6
0.4
0.2
0.0
Transmission
−0.4
−0.2
0.0
0.2
0.4
δλ(A)

Framelist options

- Cadence
  - -45-50s Doppler
  - -Integer multiple (2 or 3) for magnetic
- Combine data from two cameras?
  - -Not for Doppler! Maybe for vector?
- 5, 5.5 or 6 wavelengths?
  - -Dynamic range versus noise versus systematics
  - -Which order? Retune 0, 2 or 4 times daily?
- Polarization scheme
  - -Q, U and V separate or combined?
  - -Which order
  - -Watch out for acceleration effects

Example framelist

Time (sec)	0		8		16		24		32		40	45		53		61		69		77		85
λ Tuning	I1		I2		I3		I4		I5		IC	I1		I2		I3		I4		I5		IC
Doppler Seq	L	R	R	L	L	R	R	L	L	R	C	L	R	R	L	L	R	R	L	L	R	C
Vector Seq	1	2	2	1	1	2	2	1	1	2	C	3	4	4	3	3	4	4	3	3	4	C
Polarization	L = I + V = LCP				R = I - V = RCP				1 = I + aQ + bV			2 = I – aQ + bV				3 = I + aU – bV				4 = I – aU - bV		

Figure C.9: Details of the HMI observing sequence: *Time* indicates the beginning of the exposures at a given wavelength. The *wavelength Tuning* positions I1 through I5 are spaced evenly 75 mÅ apart, with I3 centered on the line (see Figure C.8). *Doppler Seq* and *Vector Seq* indicate the order and polarizations settings for the two cameras, with the states L, R, 1, 2, 3, 4 identified by *Polarization*. For $a^2=2/3$ and $b^2=1/3$, Q, U and V have identical noise equal to 0.22% in the continuum. IC is a continuum filtergram taken in linear polarization.

Observables construction

- Multiple steps
  - -Make I, Q, U, V, LCP, RCP
  - -Average in time, if needed
  - -Make physical observables
- I, Q, U, V construction
  - -Linear combinations of filtergrams
  - -Correct for solar rotation
  - -Correct for acceleration effects
  - -Fill gaps
  - -Flat field and polarization corrections here?
- Temporal averages
  - -May be required for vector inversions

- Velocity algorithm
  - -MDI-like:

$$V = f\left(\frac{\sum c_i I_i}{\sum d_i I_i}\right)$$

  - -For suitable f, c and d

- LOS field
  - -MDI-like: $B = c(V_{LCP} - V_{RCP})$
  - -Fancier?

- Vector algorithm
  - -Fast algorithm
  - -Full inversion

Calibration

- Ground based
  - -Various types of distortion
  - -Filter characterization
  - -Polarization characterization
  - -...
  - -MDI experience => better procedures
  - -Solar-B experience => better procedures
- On orbit
  - -Test sequences run at various times
- Data analysis
  - -New algorithms need to be developed

Calibration challenges

- Much more data
- Much larger dynamic range
  - -Higher demands
  - -But may use daily variation
- Need to consider polarization
  - -Experience from Solar-B
- But calculations may be redone!

Requirements and Performance

General Requirements

Observable	Filtergram	Instrument
Angular resolution: 1.5(1)"	Angular resolution: 1.5(1)"	Aperture: 14cm
		Jitter: 0.1"
	0.5" pixels	CCD pixels: 4096^2
Full disk	FOV: 2000" x 2000"	
99% complete 95% time	99.99% complete 95% time	Packet loss: 0.01%

Continuum intensity

Observable	Filtergram	Instrument
Cadence: 50(45)s	I framelist: 50(45)s	CCD readout
Noise: 0.3%	Intensity noise: 0.3%	Full well: $125ke^-$
Pixel to pixel accuracy: 0.1%	Flat field knowledge	Offset pointing

Numbers in () are goals. *indicates TBD. Most numbers are 1σ.

Velocity requirements

Observable	Filtergram	Instrument
Cadence: 50(45)s	V framelist: 50(45)s	CCD readout
Noise: 25(13)m/s	Intensity noise: 0.6(0.3)%	Full well: 30(125)ke$^-$
	Filter width: 76 mÅ	Element widths
	Small sidelobes	7 elements
		Element widths
Disk averaged noise: 1(0.1)*m/s	λ repeatability: 0.3(0.03)mÅ	HCM repeatability: 60(6)"
	Exposure knowledge: 200(20)ppm	Shutter: 50(5)μs
	Each cycle same λ's	Two cameras
	Effective λ knowledge:	Orbit info
Absolute: 10*m/s	λ accuracy: 3mÅ	HCM accuracy: 10'
		Filter uniformity, drift
Range: $\pm$6.5km/s (and $\pm$3kG)	Tuning range: $\pm$250mÅ	3 tuned elements
	Filtergrams @ 5 or 6 λ	CCD readout

Line of sight field requirements

Observable	Filtergram	Instrument
Cadence: 50(45)s	LOS framelist: 50(45)s	CCD readout
	LCP+RCP each cycle	LCP+RCP available
Noise: 17(10)G (Quiet Sun)	Intensity noise: 0.5(0.3)%	Full well: 40(125)ke$^-$
	High effective Lande g	FeI 6173Å (g=2.5)
Zero point: 0.3(0.2)G	λ repeatability: 0.18(0.12)mÅ	HCM repeatability: 36(24)" or No move LCP$\leftrightarrow$RCP
	Exposure knowledge: 120(80)ppm	Shutter: 30(20)μs
Range: $\pm$3(4)kG (and $\pm$6.5km/s)	Tuning range: $\pm$250mÅ	3 tuned elements
	Filtergrams @ 5 or 6 λ	CCD readout

Vector field requirements

Observable	Filtergram	Instrument
Cadence: 600(90)s	Vector framelist: 600(90)s	CCD readout
	4 states each cycle	4 states available
Polarization: 0.3(.22)%	Intensity noise: 0.4(0.3)%	Full well: 70(125)ke$^-$