Secondary scientific objectives for SODISM

J.-F. Hochedez
F. Auchère, T. Dudok de Wit, M. Kretzschmar, M. Haberreiter, E. Quémerais, T. Roudier
Introduction

• SODISM primarily designed for geometric and radiometric metrology at the solar limb
  – Most telemetry, shutter operations, calibration analysis devoted to primary objectives:
    • limb metrology
    • disc & limb helioseismology

• Yet, SODISM is a general purpose solar NUV-VIS telescope producing
  – Synoptic still images (20 per day in all channels)
  – image sequences displaying --or not-- solar events (a few special campaigns)

• Hence, secondary objectives (non limb, non oscillatory), of 2 types:
  – Investigations of individual features
    • together with non-SODISM instruments
  – Statistical investigations
    • Spatial dependencies: center-to-limb, latitudinal, North-South...
    • Temporal dependencies: Schwabe activity cycle, intermittency, other cycles...

+ Some non-strictly-solar targets of opportunity arise
  – Occultations by the Earth atmosphere during the “eclipse season” (winter)
  – Venus transit in June 2012 + (Mercury transit in May 2016 and Nov. 2019…)
  – Solar eclipses by the Moon (2-3 per year)
  – Stellar observations
## Original SODISM science fields

<table>
<thead>
<tr>
<th>Field</th>
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| **Solar limb metrology (Sci.field.1)** | - Radial profile of the limb  
- Angular profile of the solar disc (asphericity and higher moments)  
- Temporal evolution of the above |
| **Helioseismology (Sci.fld.2)** | - Helio-seismic diameter  
- Solar intensity oscillations, and especially g-modes |
| **Solar spectral irradiance (Sci.fld.3)** | - Contribution to the reconstruction of the SSI (solar spectral irradiance) |
| **Other solar physics studies (Sci.fld.4)** | - Surface motions and their evolution  
- Study of magnetic activity features  
- YOUR IDEAS HERE! (Serendipity) |
| **Solar-terrestrial relationships & aeronomy (Sci.fld.5)** | - Space Weather  
- Studies of the Earth atmosphere via occultations, albedo studies, etc.  
- Contribution to understanding the Sun-Earth connection and climate |
Secondary objectives enabled by SODISM data
discussed in this talk

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The astrophysical content of secondary SODISM observations

1. Content of still images
   a. The “featureless” non-magnetized photosphere
      • Its center-to-limb variation, latitudinal dependence, evolution, etc.
   b. Photospheric objects
      • Sunspots, faculae
   c. Chromospheric objects
      • Chromospheric network, plages

2. Content of image sequences
   a. Eventless
      • Torsional oscillations, meridional circulation, supergranular pattern
   b. Eventful
      • Solar: White-light flares, Moreton waves, eruption signatures, etc.
      • Non solar: eclipses by the moon, Earth occultations
A meek classification
The 5 dimensions of SODISM data analysis

- Studied dependences
  - Temporal (scales)
  - Spatial (scales)
  - Spectral

- Method
  - Case study
  - Statistics

- Measurement
  - Morphology
  - Motion
  - Radiometry

- SODISM science investigations

- SODISM channel
  - Photospheric
  - Chromospheric

- Primary target
  - Eventless region
  - Solar object
  - Non solar event
Intensity as a function of latitude

GI suggestions #1

• Radiative North-South asymmetry of the NUV-NIR sun
    • How uniform can a solar-like stellar disk be?
      ➔ Exoplanets research
    • Is magnetism the sole source of irradiance variation?
    • North-South asymmetry
      – In continuum and Fraunhofer lines from 313.4 nm to 4 688 nm
      – Non magnetic photosphere (solar minimum conditions, 2007)
      – 0.05% in the IR
      – 1% in the violet and UV
      – 15% in photospheric and chromospheric line cores
      – Faculae = probable source for the measured asymmetries

• Latitudinal variation of the photospheric intensity
    • Baroclinicity expected for models to match differential rotation
      – Poles and equator regions few K warmer than mid-latitudes
    • Contrasts in the red [•] and in the blue [○] ➔
      – Non magnetic photosphere (outside faculae)
      – inside 0.3 < µ < 0.45
    • Contradicted by Livingston, Galayda, Milkey (2011)

• NB: benefit of eclipses
Evolution of the supergranular pattern
GI suggestions #2

- **Meunier, Roudier, Rieutord, AA (2008)**
  “Supergranules over the solar cycle”
  “Comparisons of supergranules characteristics during the Solar Minima of cycles 22-23 and 23-24”

- Supergranules observed by T. Roudier with SODISM
  - 535nm, 3min cadence
  - LCT technique
  - Cf. J.-M. Malherbe’s talk

*Fig. SODISM 535nm divergence field T. Roudier, April 2012*
Chromospheric investigations
GI suggestions #3

• 215 nm
  – Uniqueness of such imaging observations
  – “terra incognita”
  – 1 lossless image per day
  – Synergies with PREMOS

• 393 nm
  – 11 (lossy) images per day!
  – Modeling Ca II K emission (<500km?)
  – Proxy (tbc) for the horizontal magnetic field away from disc center

  – ΔD ~ 2 arcsec in H-alpha
  – ΔD ~ 10 arcsec in He II
  – ΔD ~ 10 mas in the photospheric continuum
  – Dynamical vs. magnetic pressure interplay
  – ΔD at 215nm and 393nm ??
  – Cycle evolution?

SODISM 215nm
2011-04-01

393 emission height, from Ermolli et al 2012

Hell prolateness, from Auchère et al 1998
SSI reconstruction
GL suggestions #4

• Segmentation based on intensity in 1 channel
  – use several, segment on morphology!
• Assign atmosphere (and spectrum) to segmented region
  – SRPM: Fontenla et al
  – SolMod3D: Haberreiter et al (COSI & SRPM heritage)
White Light Flares
GI suggestions #5

- Eruption, as seen by PREMOS 210 nm →
  - SODISM could observe such events
- Veselovsky and Koutchmy (2009)
  Scientific requirements for future spatially resolved white-light and broad-band high-cadence observations of the Sun
- Martínez Oliveros et al (2011)
  Imaging Spectroscopy of a White-Light Solar Flare
  Eruption seen by SDO - HMI
Observation of the Sun occulted by the Earth atmosphere
GI suggestions #6
GI suggestions #7: Venus transit of June 2012
Classification of expected hurdles

**Measurement type**
- Morphological & motion
  - on disc
- Radiometric
- Solar features and events
- Non magnetic photosphere

**Primary target**
- Photospheric
- Chromospheric
- Temporal short term or Spatial small scale
- Temporal long term (months)
- Spatial large scales (CLV, North-South, etc.)
- Spectral

**Channels**
- PSF deconvolution, flatfield (small scales)
- Persistence, flatfield (all scales), QE, camera gain, ghosts, dark current, cosmic ray hits
- Chance of capturing sought event, max cadence = 1 minute
- Magnetic activity filtering
- OK
- Sensitivity loss
- OK
- Calibration evolution (PSF, flatfield, dark current, etc.)
- Flatfield (large scale)
- Relative calibration

**Color code:**
- Not so bad, promising, or better than feared
- Difficult

Picard Workshop - 2012-04-10
Secondary Sci. Obj. - JFH et al
SODISM aptitudes and frailties

• **Weaknesses**
  – Unknown PSF
  – Unexplained persistence
  – Quasi all full disc images compressed lossily, what’s more at x16 rate
  – Few sequences of full frame images, none yet acquired at the max cadence of 1 minute
  – Sparse exploration of the space of image acquisition parameters
    • E.g. fixed exposure time
  – Ghost and scattered light
    • Difficult off-limb observations

• **Plusses**
  – 24h/7d operations
  – Potentially frequent Z-axis rotation → large scale flatfield precision (if full frames)
  – Uniqueness of the 215 nm channel
  – Plurality and narrowness of the passbands
  – Stability of the telescope body
  – Relatively frequent solar eclipse observations
  – Earth occulted observations in winter
  – No technical impossibility for NRT (near real time) data delivery, but presently unavailable
Expected collaborations

– PREMOS filter radiometers
– Solar full-disc imaging monitors
  • PSPT, SOLIS, and other ground-based telescopes
  • SDO-HMI, SDO-AIA
– SOVAP and PREMOS TSI radiometers
– Others (SORCE - SIM, PROBA2 - LYRA, etc.)

– Join internationally coordinated observations

– Guest investigators!