Seismology with PICARD

Objectives and results


Many Contributions/inputs from GEVP and PICARD team
Helioseismic objectives

1. Structure and dynamics of the nuclear core
   (limb helioseismology or “HL” program and integrated irradiance data ; low
   frequency domain of the solar oscillation spectra; low and intermediate degree
   modes).

2. Nature of the modes, convection, photospheric physics
   (Intensity Medium-I program or "Macro Pixels" program)

3. Fundamental (f) modes and the solar radius ("Macro Pixels" program)

Corbard, Boumier, Appourchaux et al 2008
First glance at the observables
g-modes search with PICARD: take advantage of limb-amplification

- This limb amplification is understood theoretically (Toutain et al., 1999) and it has been observed for p modes using MDI images and LOI guiding pixels. (Appourchaux et al. 1996)

- PICARD: searching low frequency modes.
HL limb shape analysis

2011/04/17
Cadence: 1 image/2 mn
Angular resolution: 0.02 deg
Radial resolution: 0.02 pixels

South Pole
Radial extent: 15 pixels
North Pole
HL limb shape analysis

2011/04/17
Cadence: 1 image/20 mn
Angular resolution: 0.02 deg
Radial resolution: 0.02 pixels

North Pole

South Pole

Radial extent : 4 pixels

North Pole
HMP

max scattered light ~ 10% of mean image intensity
Central spot appears on 2010/11/21
Important change in scattered light shape and intensity starting 2011/03/31
HMP integrated photometry

$\Delta I/I \sim 0.03\%$ peak to peak
Correlated to orbital position
CCD Remanence/Persistence

Integrated HMP flux during February

Color shows what type of measurement was made the minute before

\[
\frac{[I(535H) - I(CO)]}{I(535H)} = 0.2\% 
\]
Operational duty cycle

SAA $\Rightarrow$ $\sim$ 5% less $\Rightarrow$ $\delta < 60\%$; target: [70-78] %

SAA $\Rightarrow$ $\sim$ 5% less $\Rightarrow$ $\delta < 70\%$; target: [85-90] %
HMP RESULTS
Blue lines: modes with turning points at 0.4, 0.85 and 0.95 \( R_\odot \) from the left to the right.
$l=50$ spectrum

Diameter sampling: not randomly distributed on the orbit
Solar rotation

2 consecutive radial harmonics of $l=99$ mode (with leakage from other degrees).

Straight line $\Rightarrow$ uniform rotation ; S-like lines $\Rightarrow$ differential rotation
M-nu spectra: rotation coefficients measurements

Central frequency = 2906.920 +/- 0.002 Hz

\[ a(1) = 409.463 +/- 0.100 \]
\[ a(2) = -0.725 +/- 0.121 \]
\[ a(3) = 19.877 +/- 0.141 \]
\[ a(4) = -0.163 +/- 0.146 \]
\[ a(5) = -4.508 +/- 0.144 \]
\[ a(6) = -3.905 +/- 0.150 \]
Mode parameters: First results from PICARD
Limb RESULTS
Limb signal

SODISM HL (N1) 2011 - April 14, 15 & 16

Temporal frequency (Hz)

Angular wave number
Optimisation of the signal/noise

Signal obtained on a sub-wing at $R/R_\odot < 1$: find the optimum!

22 pixels PICARD
Understand the link between HL and HMP
$(l', \nu)$ diagram of the HLs
Shift between ridges

Power along the $n=8$ ridge
- In white: $(l, \nu)$
- In green: $(l', \nu)$
Time-distance with the LPs
Organisation / future

• 12/2008 : Helas workshop; Nice; « getting ready for PICARD Helioseismology program ».

• Letter of Interest: 4 answers; presented to the Scientific Committee in May 2009.

• 2010-2012: data reduction and analysis; « revisite of the scientific objectives ». Define a program with other filters like 393 nm ?

• 2012: call for « guest investigators ».
Mode parameters: results from GONG
global duty cycle (from the beginning)

SAA ⇒ ~ 5% less ⇒ δ < 60%; target: [70-78] %

SAA ⇒ ~ 5% less ⇒ δ < 70%; target: [85-90] %
Diameter sampling: not randomly distributed on the orbit