What good are multiple bounces, anyway?

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1.1 - HMI Data Products

Doppler Velocity

- Heliographic Doppler velocity maps
  - Spherical harmonic time series to \( l=1000 \)
  - Mode frequencies and splitting
  - Internal rotation \( \Omega(r,\theta) \) (\( 0 < r < R \))
  - Internal sound speed, \( c_s(r,\theta) \) (\( 0 < r < R \))
  - Full-disk velocity, \( \mathbf{v}(r,\theta,\phi) \), and sound-speed, \( c_s(r,\theta,\phi) \), maps (0-30 Mm)
  - Carrington synoptic \( \mathbf{v} \) and \( c_s \) maps (0-30 Mm)
  - High-resolution \( \mathbf{v} \) and \( c_s \) maps (0-30 Mm)
  - Deep-focus \( \mathbf{v} \) and \( c_s \) maps (0-200 Mm)
  - Far-side activity index

- Ring Diagrams
  - Local wave frequency shifts

- Tracked Tiles of Dopplergrams
  - Time-distance cross-covariance function
  - Wave travel times
  - Egression and ingressions maps
  - Wave phase shift

Filtergrams

- Stokes I, V
  - Full-disk 10-min averaged maps
    - Line-of-sight Magnetograms
      - Dynamic whole-Sun magnetic field maps

- Stokes I, Q, U, V
  - Tracked Tiles
    - Vector Magnetograms Fast algorithm
      - Dynamic coronal magnetic field maps
  - Continuum Brightness
    - Tracked full-disk 1-hour averaged continuum maps
      - MHD coronal field and solar wind models

- Continuum Brightness
  - Brightness features maps
  - Solar limb parameters
  - Irradiance models
Filtered (r/R=.96) correlation

\[ \Delta \text{[deg]} \]

\[ \text{time [hr]} \]
rays focused at \( r/R = 0.79 \)
Figure 4.13: Deep-focusing travel-time kernels, $\tilde{K}$, for sound speed. The solid line is for a focus depth of $0.65R_\odot$ (39 min), the dashed line is for $0.8R_\odot$ (31 min), and the dot-dashed line is for $0.975R_\odot$ (13 min). The lower horizontal axis is acoustic depth, in minutes. The upper horizontal axis is fractional radius. An acoustic depth of 60 min corresponds to the center of the Sun and 0 to the solar surface. Notice that all three of the kernels are similar near the surface (small acoustic depth). The kernels are mostly negative, i.e. an increase in sound speed leads to decreased travel time. Also notice that the kernel for the deepest focus depth (solid line) has weight at greater depth than the other two.
Figure 4: Wave theoretic sensitivity kernels for the ray configurations shown in figure 1. The top panel shows a kernel for surface focus data while the bottom panel shows one for deep focused data.
ew travel time difference for perturbed simulation, r/R=.92

ew travel time difference for unperturbed simulation, r/R=.92

noise-corrected ew travel time difference, r/R=.92

Input flows at r/R=.92
spatial rms velocity versus depth for different simulations

- $r/R = 0.79$ case
- $r/R = 0.86$ case
- $r/R = 0.92$ case
- $r/R = 0.96$ case
- $r/R = 0.98$ case
- $r/R = 0.99$ case

soundspeed/50

$\lambda$

$\lambda/4$
response to .79, .99 flows for .79 focusing
response to .99 flows with footpoint locations for .79 focusing
Focusing at $r/R=0.79$, skip=2
response to .79, .99 flows for .79 focusing, skip=2
Plot of 4 skips at distance $n \times 13.92$ deg; centered at $n \times 64.66$ m

Plot of 4 skips with correlation multiplied by $(-1)^n$

4 skips with sign, amplitude corrected
theory correlation

observed correlation

time, min

$\Delta [\text{deg}]$

theory, $\Delta=10$ deg.

observations, $\Delta=10$ deg.

$\times 10^5$

time, min
response to vertical perturbation at $r/R=0.79$