Interpretation of HMI Local Helio. Data

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We will need:

- knowledge of the instrument
- reference models
- forward problem
- inverse problem
- codes

Models

- in order to do inversions need a reference model
- want reference model close to real Sun + instrument
- need to model:
  - source of waves
  - damping (scattering, non-adiabaticity)
  - instrumental effects

The Forward Problem

given a model, how to compute expectation of the measurements ?

- physical (solar) effects
  - finite wavelength
  - distributed sources
  - correlated noise ?
  - convection / turbulence
  - damping by scattering
  - non-adiabatic effects
  - non-linear effects
- noise issues
  - need noise covariance for inversions

The Inverse Problem

- many physical variables can alter data
  - flows
  - sound speed
  - density
  - magnetic field
  - damping
  - source properties
- in general both scattering and direct effect
- invert simultaneously for many quantities, cross-talk
- strong perturbations, what happens when linear approx. fails ?

Codes

- time-distance analysis code, want to choose
  - filters
  - definition of travel time
  - travel-time kernels
  - inversion method, regularization parameter
- possible extensions to use
  - amplitude, central frequency, width
  - shifts in individual phase peaks, zeros
  - full waveform

Example Physical Model

- plane-parallel, constant $\mathbf{g}$
- stratified
- random distributed wave sources
- equations:

$$\rho \frac{D\boldsymbol{v}}{Dt} + \nabla p + \rho \mathbf{g} + \rho \Gamma \boldsymbol{v} = \mathbf{s}$$

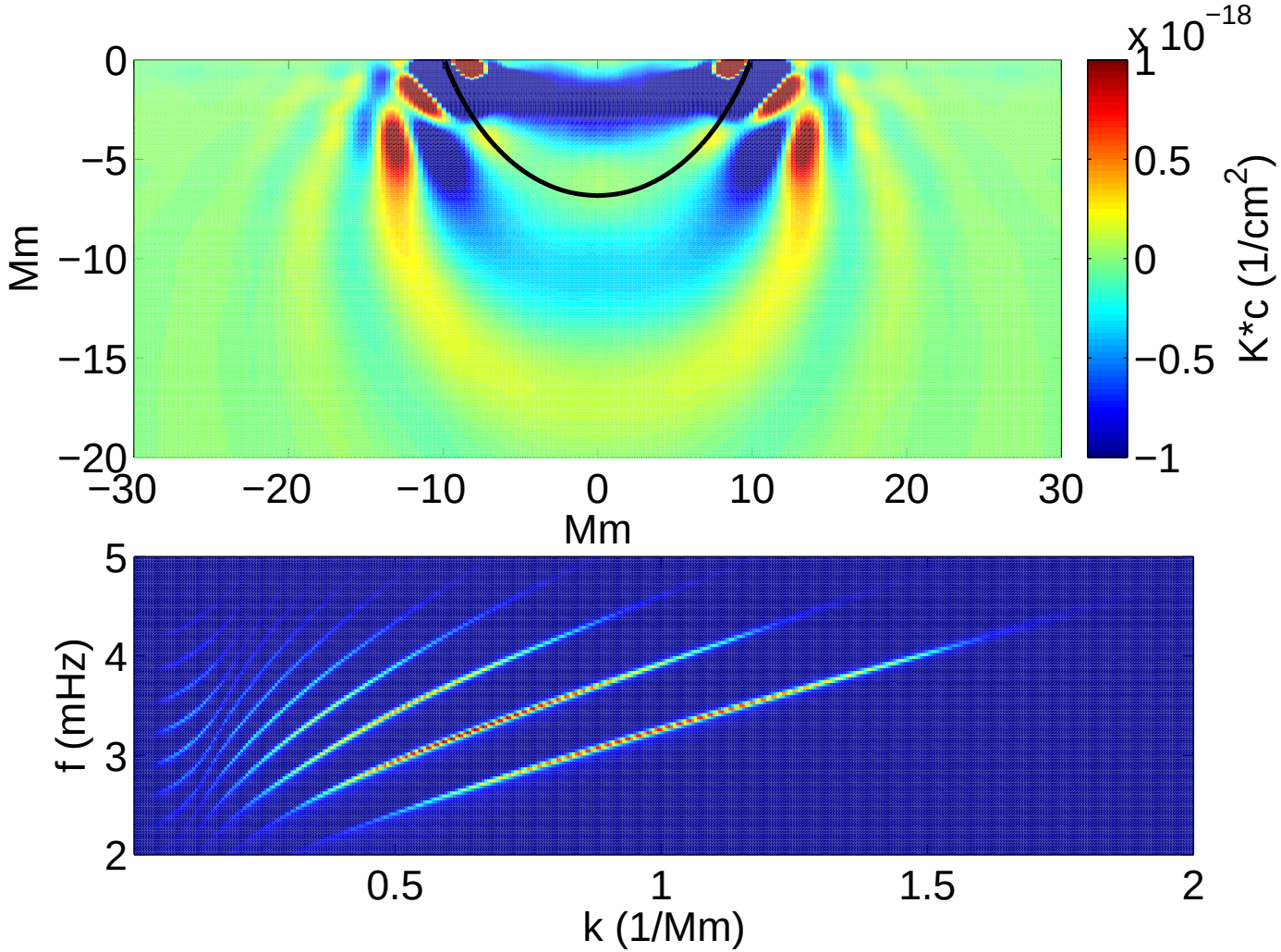
$$\dot{\rho} + \boldsymbol{\nabla} \cdot \{\rho \boldsymbol{v}\} = 0$$

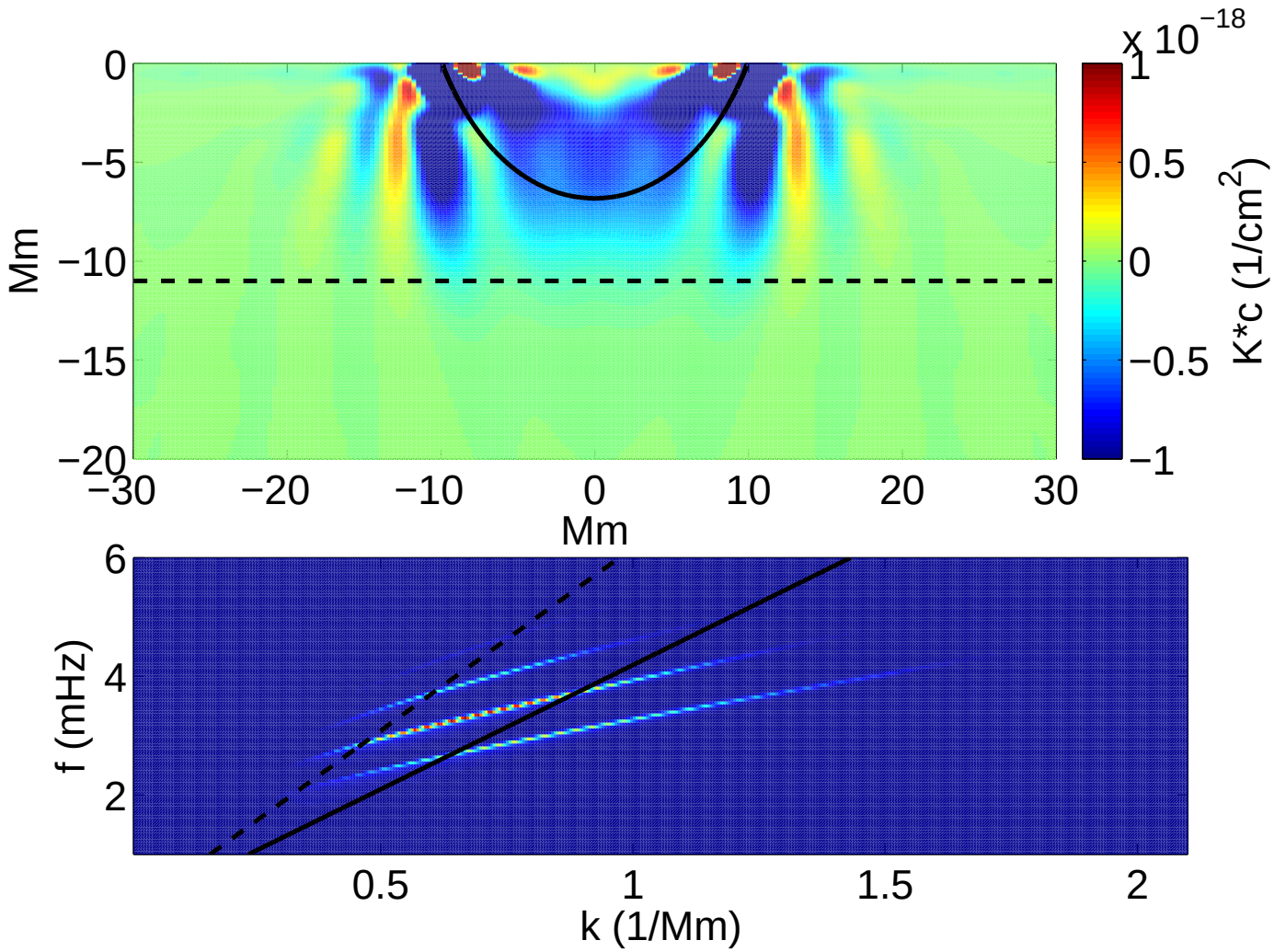
$$\frac{Dp}{Dt} = c^2 \frac{D\rho}{Dt}$$

- boundary conditions:
  - at the top: $\delta p = 0$
  - at the bottom: $\boldsymbol{v} \cdot \hat{z} = 0$

Sound-Speed Kernel

$$\delta t = \int_{\odot} \mathrm{d}\boldsymbol{r}\; K(\boldsymbol{r})\, \delta m(\boldsymbol{r})$$



Phase-Speed Filter

include a filter