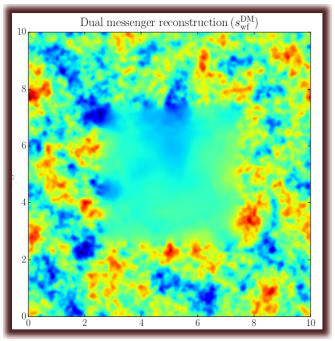
Optimal & fast Wiener filtering of CMB maps without preconditioning

Doogesh Kodi Ramanah[1,2], Guilhem Lavaux[1,2], Benjamin D. Wandelt[1,2]

[1]IAP/CNRS, [2]ILP

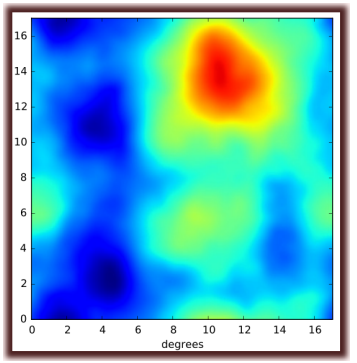
(DKR, Lavaux & Wandelt 2017)



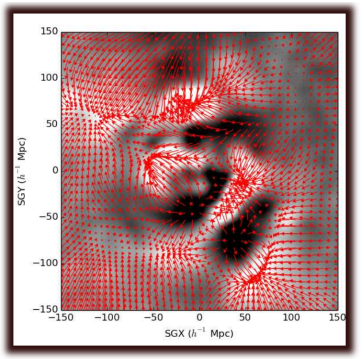
Map-making

(Anderes, Lavaux & Wandelt 2015)

Lensing



(Lavaux 2017, in prep.)



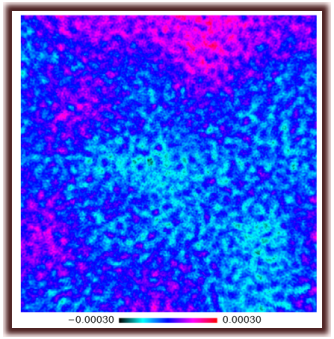
Velocity field

CMB

LSS

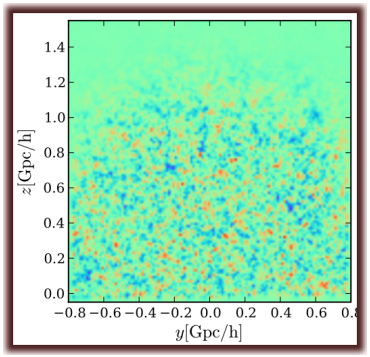
Wiener Filter

(Elsner & Wandelt 2008)



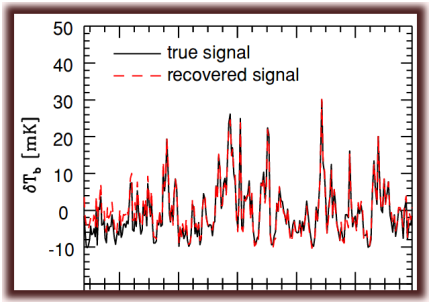
Non-Gaussianity

Density field



(Jasche & Lavaux 2015)

21-cm field



(Gleser+ 2008)

- **Power spectrum estimation**
- **Likelihood analysis**
- **De-lensing**
- **Foreground removal**
- **Template-matching**

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Wiener Filter

- Signal reconstruction from noisy data
- **Optimal** data analysis solution for Gaussian Random Fields ≈ Cosmic density field

Conventional Methods

- Preconditioned Conjugate Gradient (**PCG**)
- Preconditioner,
  - ✗ **Problem-dependent**
  - ✗ **Ill-conditioning issue**
  - ✗ **Numerically expensive & unstable**
- High level of complexity
- Difficulties in dealing with CMB polarization

Wiener filter equation

$$(\mathbf{S}^{-1} + \mathbf{N}^{-1})\mathbf{s}_{\rm wf} = \mathbf{N}^{-1}\boldsymbol{d}$$

Signal covariance | Noise covariance | Wiener filter solution | data

Dual Messenger Algorithm

- Fast & efficient preconditioner-free algorithm
- Deals effectively with CMB polarization data, while PCG fails to converge to a sensible solution
- Unconditionally stable & trivial numerical implementation
- Relevant for current & next-generation CMB experiments.

→ Algorithm can be augmented to deal with more complex & realistic noise models

→ Exact global Bayesian analyses (Gibbs sampling) for optimal separation of pure *E*- & *B*-modes

(**DKR, Lavaux & Wandelt 2017, MNRAS**) → **arXiv:1702.08852**