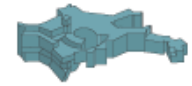
Max Planck Institute
for Astrophysics



The Galactic Faraday sky

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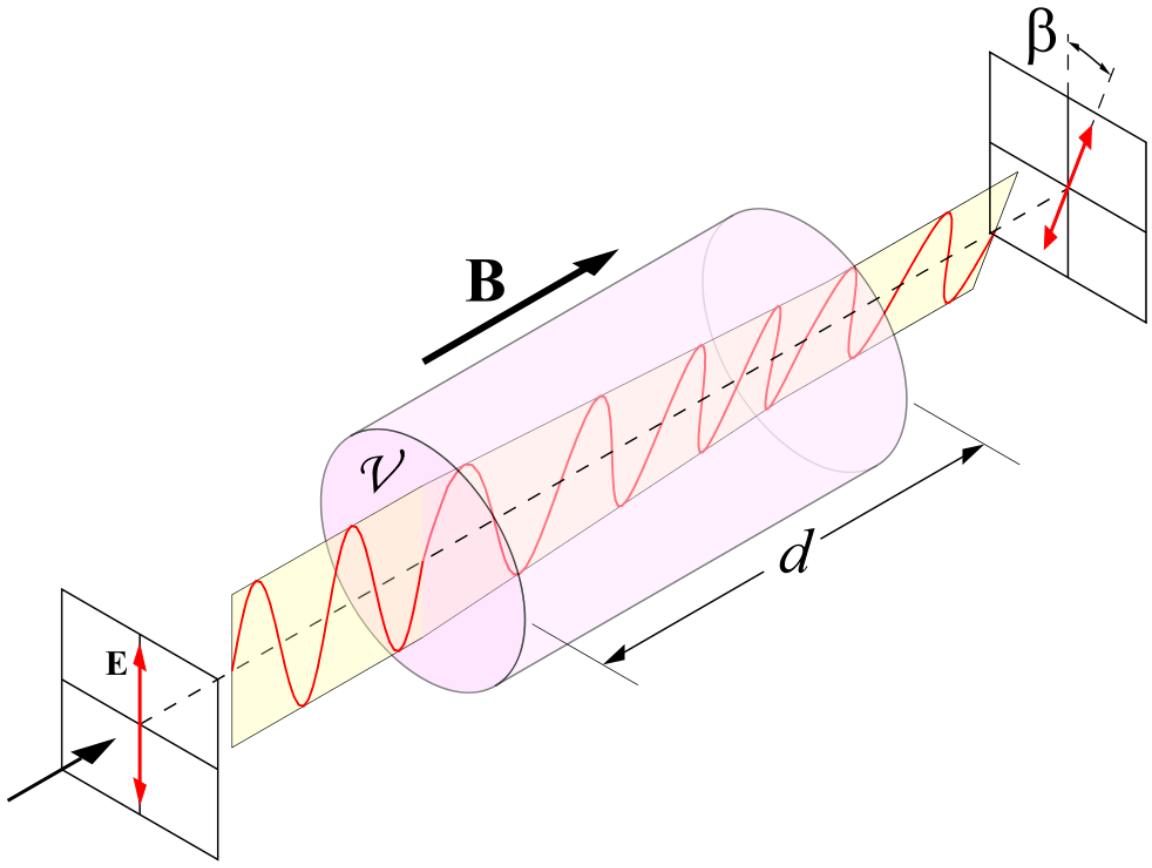
What it is, how it's done, and why it's useful

Niels Oppermann

with
H. Junklewitz, G. Robbers, M.R. Bell, T.A. Enßlin, A. Bonafede, R. Braun, J.-A.C. Brown, T.E. Clarke, I.J. Feain, B.M. Gaensler, A. Hammond, L. Harvey-Smith, G. Heald, M. Johnston-Hollitt, U. Klein, P.P. Kronberg, S.A. Mao, N.M. McClure-Griffiths, S.P. O'Sullivan, L. Pratley, T. Robishaw, S. Roy, D.H.F.M. Schnitzeler, C. Sotomayor-Beltran, J. Stevens, J.M. Stil, C. Sunstrum, A. Tanna, A.R. Taylor, and C.L. Van Eck

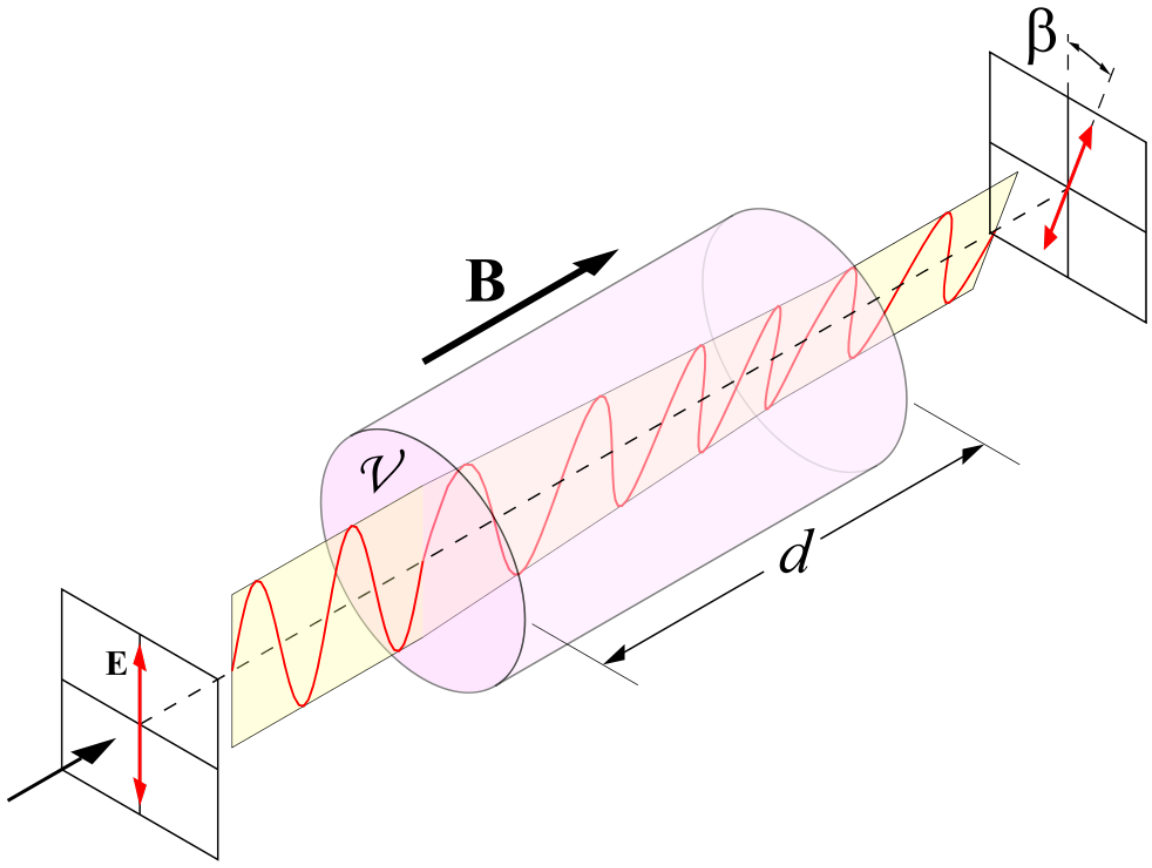
Bologna, 2012-02-14

What it is



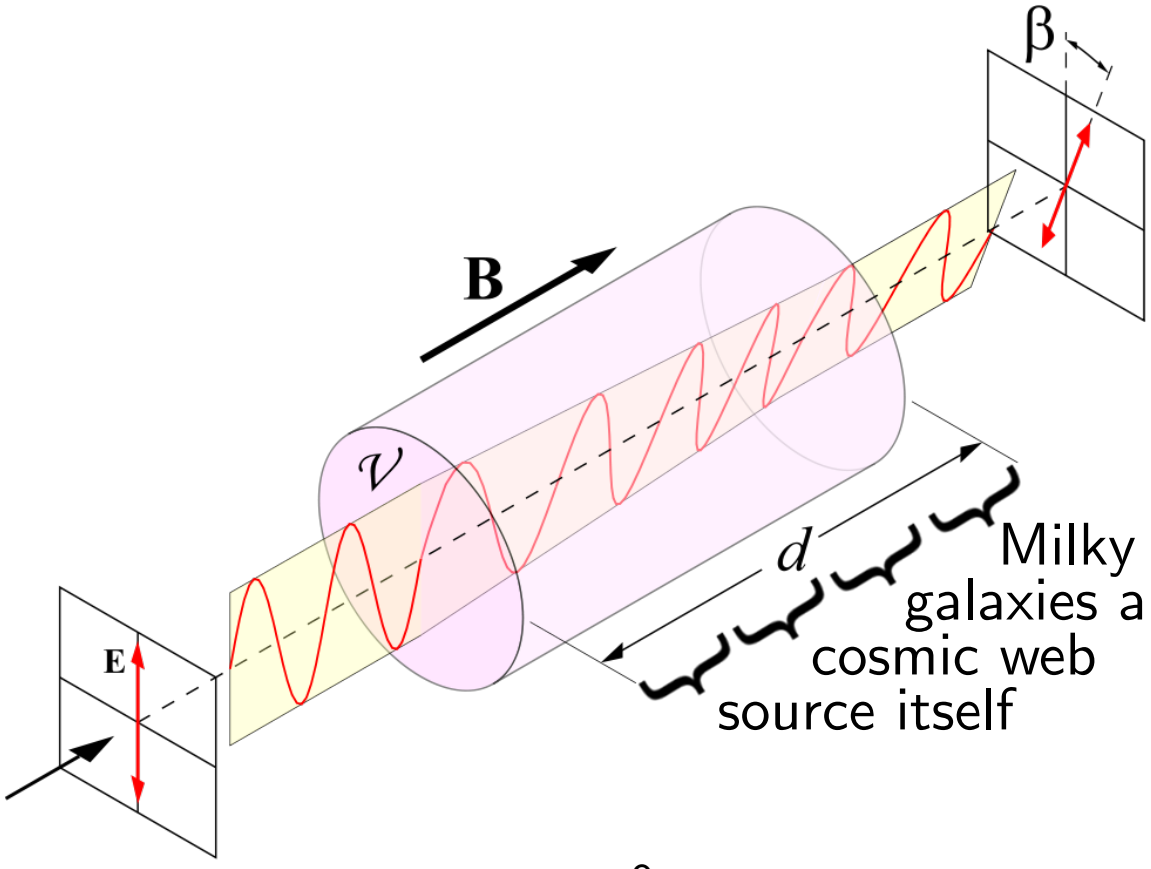
$$\mathrm{d}\beta \propto \lambda^2 n_\mathrm{e}(\vec{x}) B_r(\vec{x}) \mathrm{d}r$$

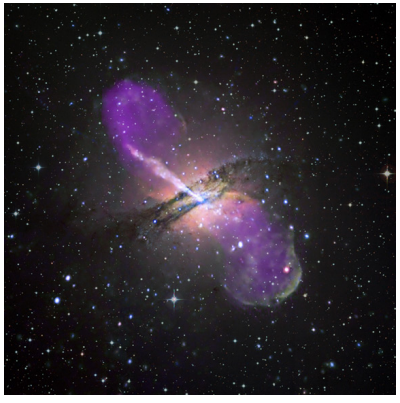
$$\Rightarrow \quad \beta \propto \lambda^2 \int_{r_\mathrm{source}}^{0} n_\mathrm{e}(\vec{x}) B_r(\vec{x}) \mathrm{d}r$$



Faraday depth: $\phi \propto \int_{r_{\mathrm{source}}}^{0} n_{\mathrm{e}}(\vec{x}) B_r(\vec{x}) \mathrm{d}r$

$$\beta = \phi \lambda^2$$





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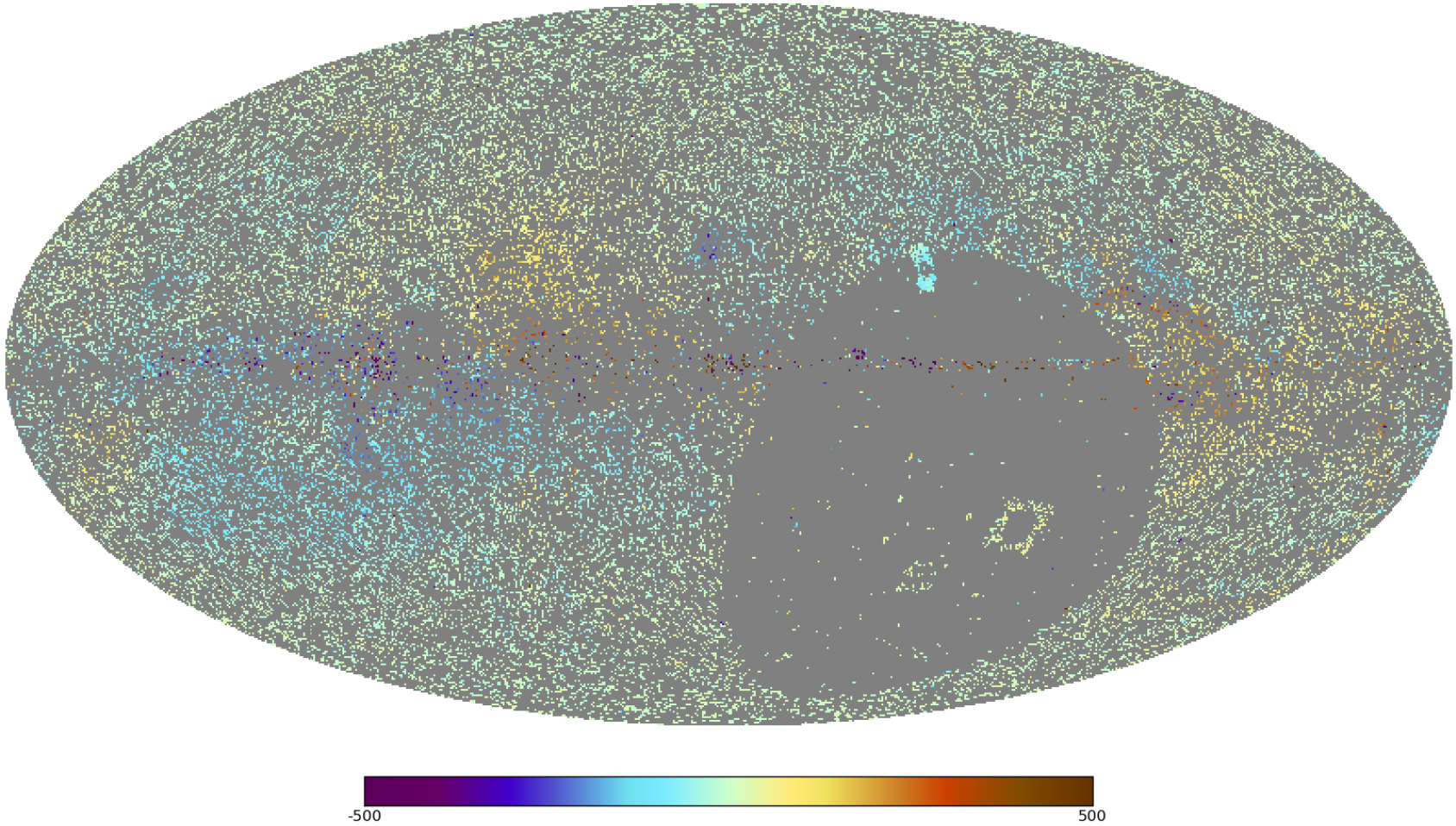


41 330 data points

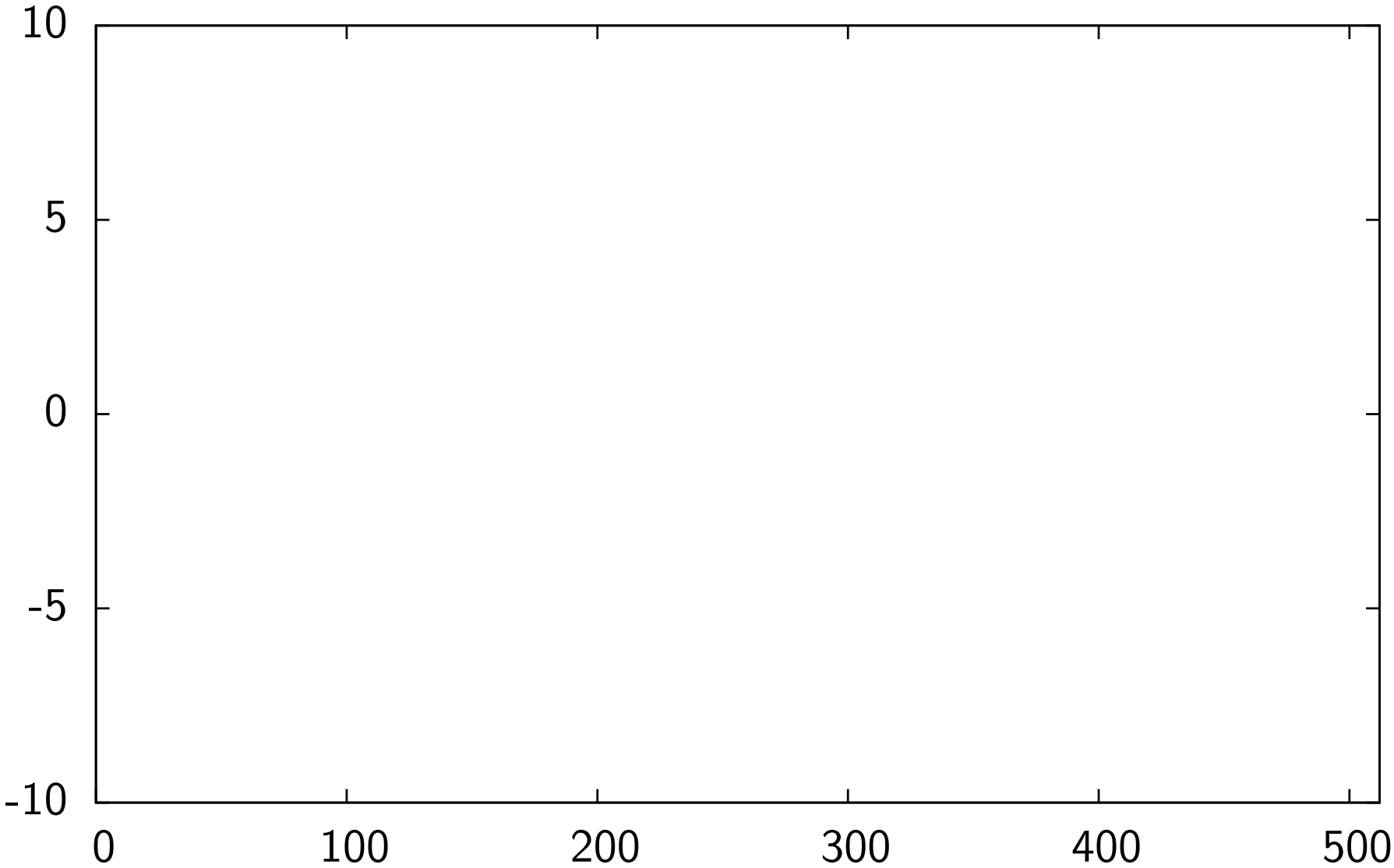
How it's done

Use Extended Critical Filter (ECF) developed within *Information Field Theory* (see Torsten Enßlin's talk on Thursday)

Oppermann et al. 2011PhRvE..84d1118O

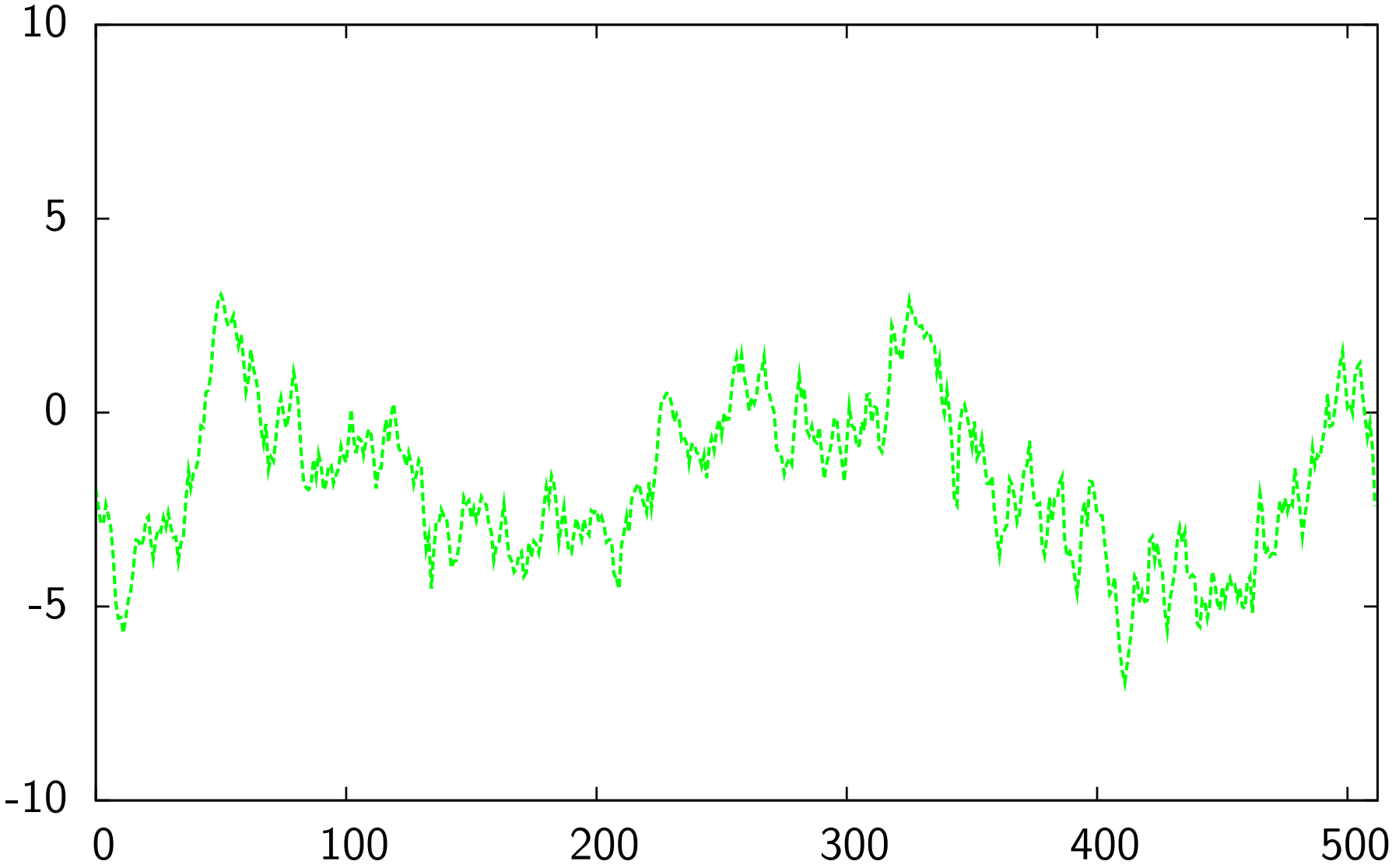
Assumptions:

-
-



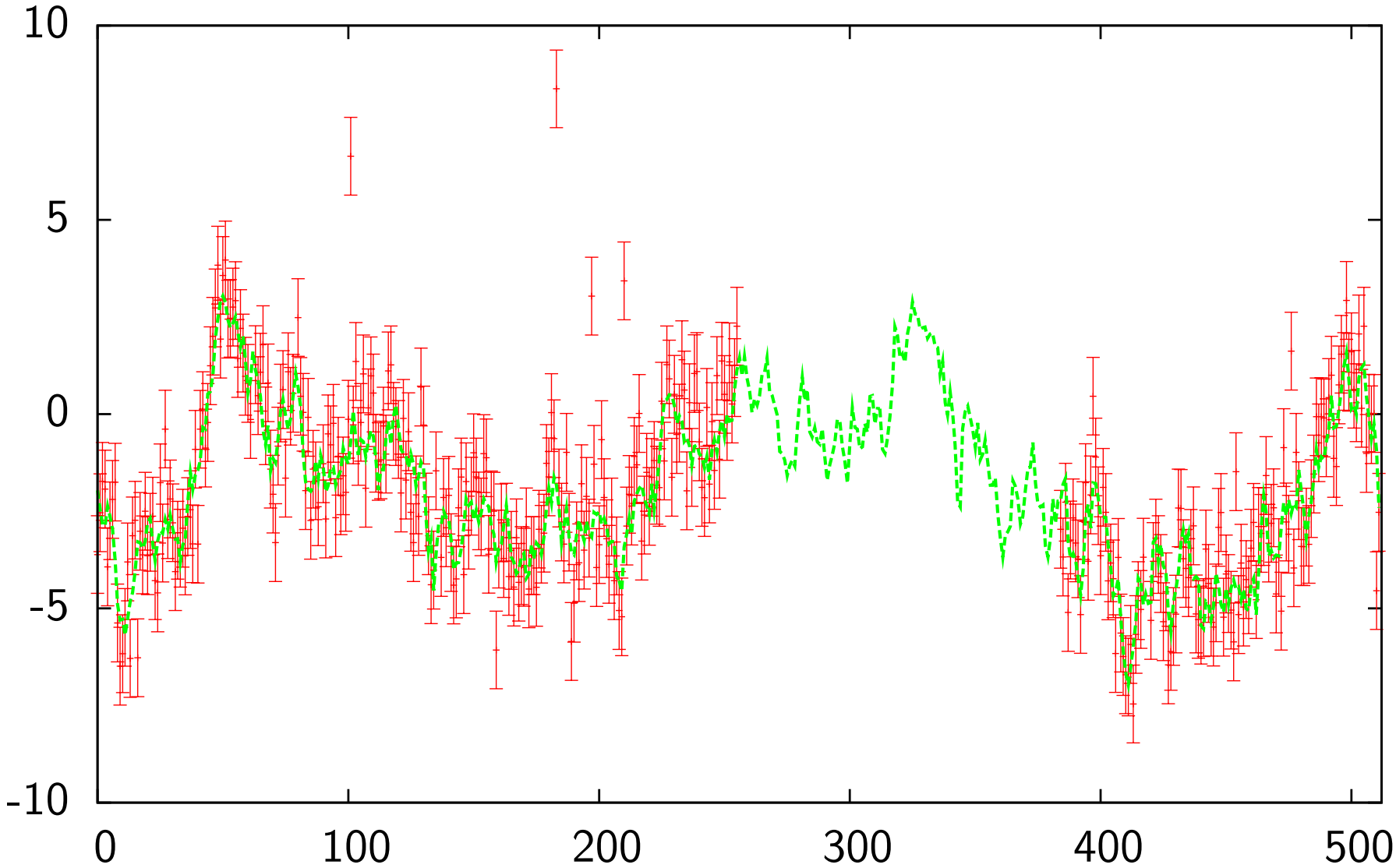
Assumptions:

- signal field statistically homogeneous Gaussian random field
-

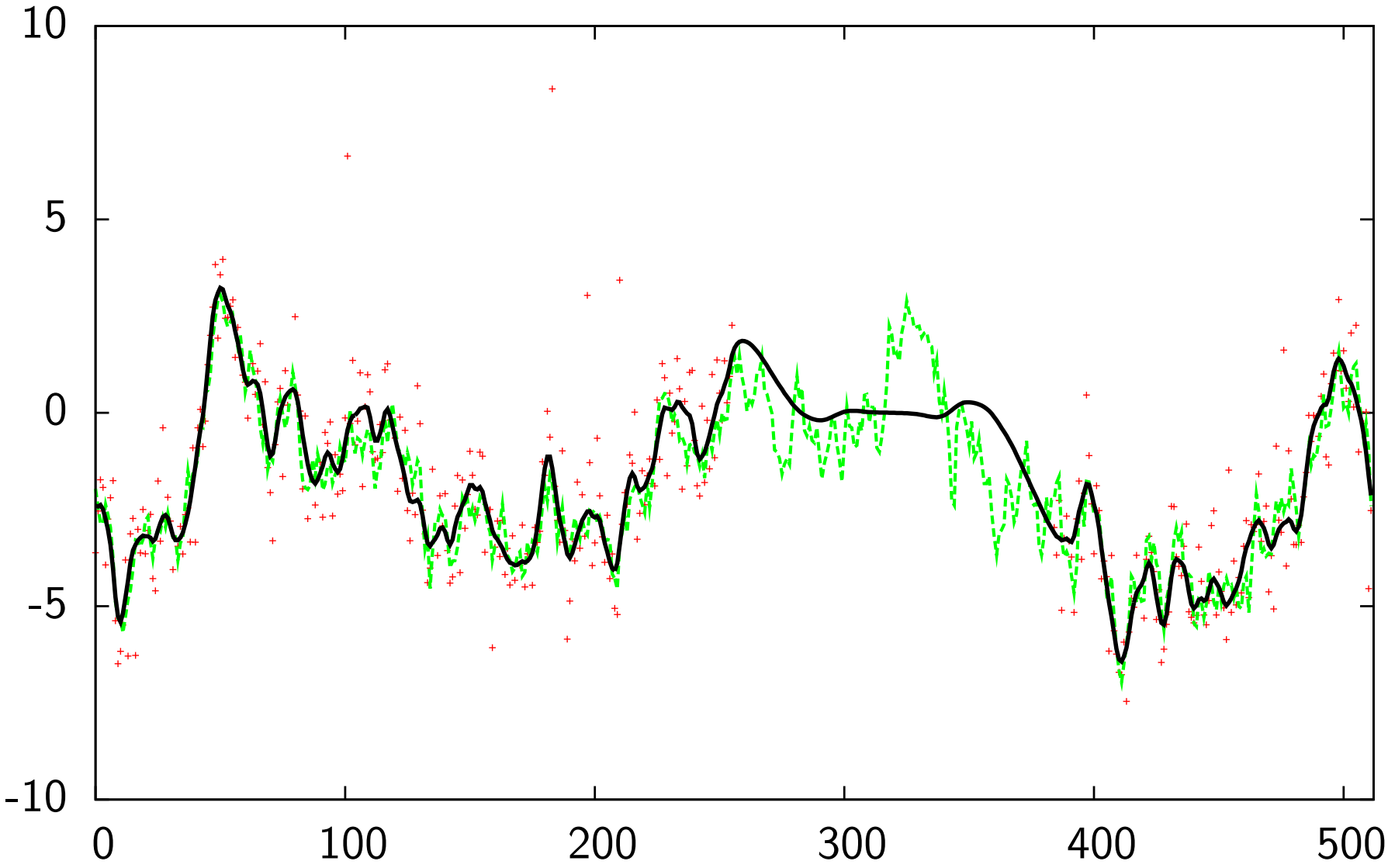


Assumptions:

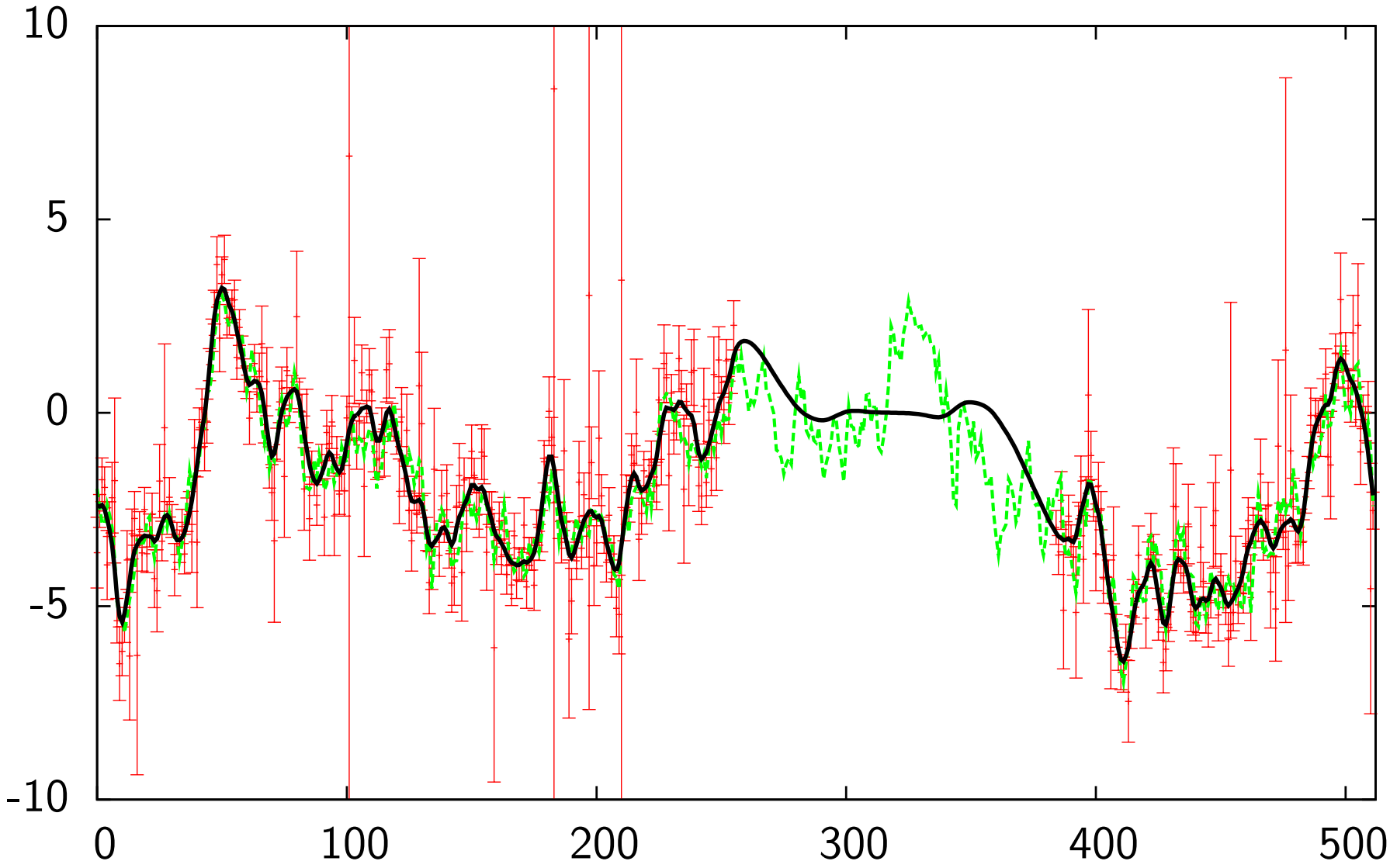
- signal field statistically homogeneous Gaussian random field
- noise uncorrelated, Gaussian

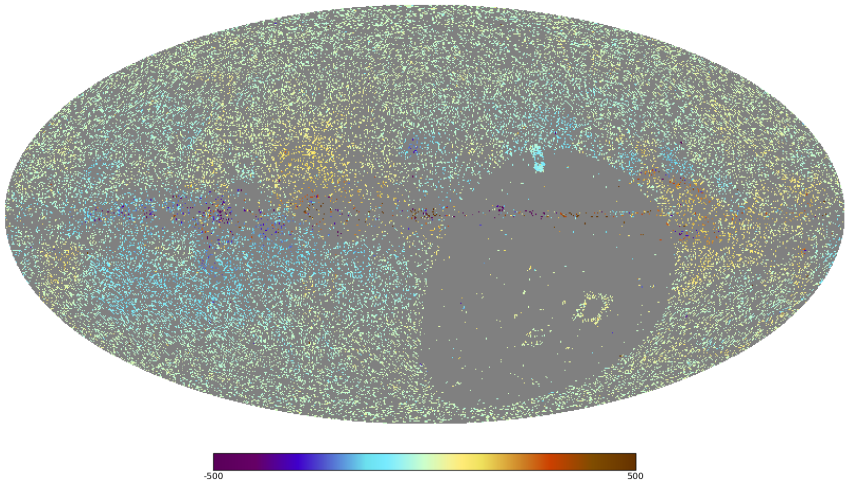


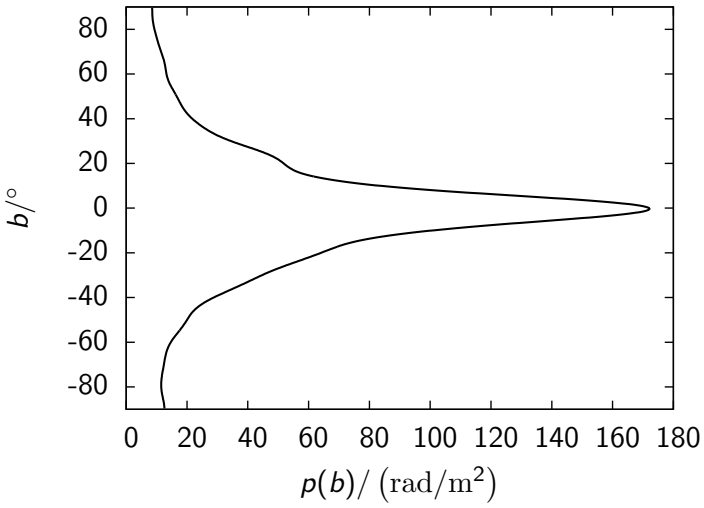
- Reconstruct (iteratively):
  signal, power spectrum, noise variance



- Reconstruct (iteratively):
  signal, power spectrum, noise variance

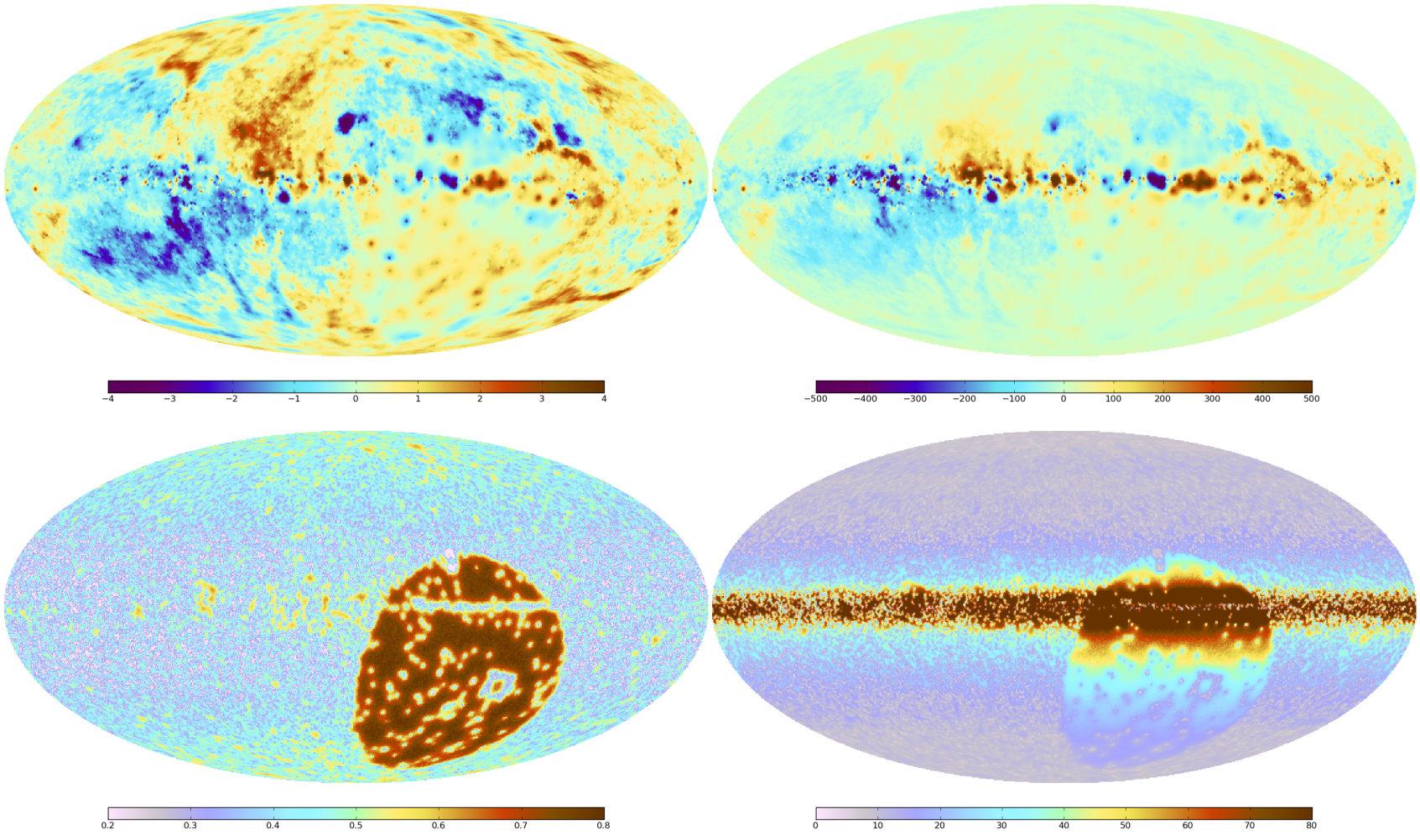






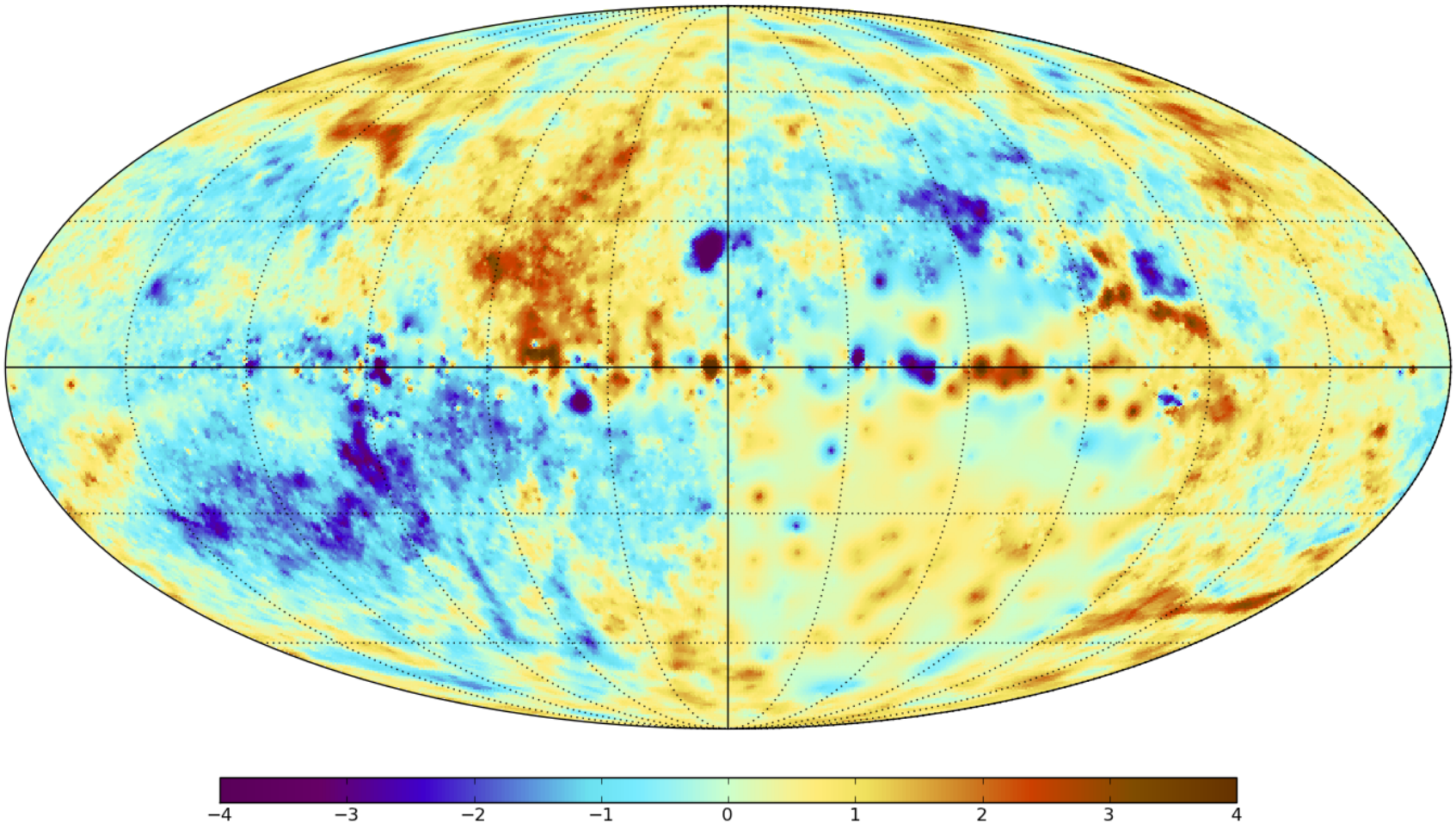
$$d_i = p(b_i) \times s(b_i, l_i) + n_i$$

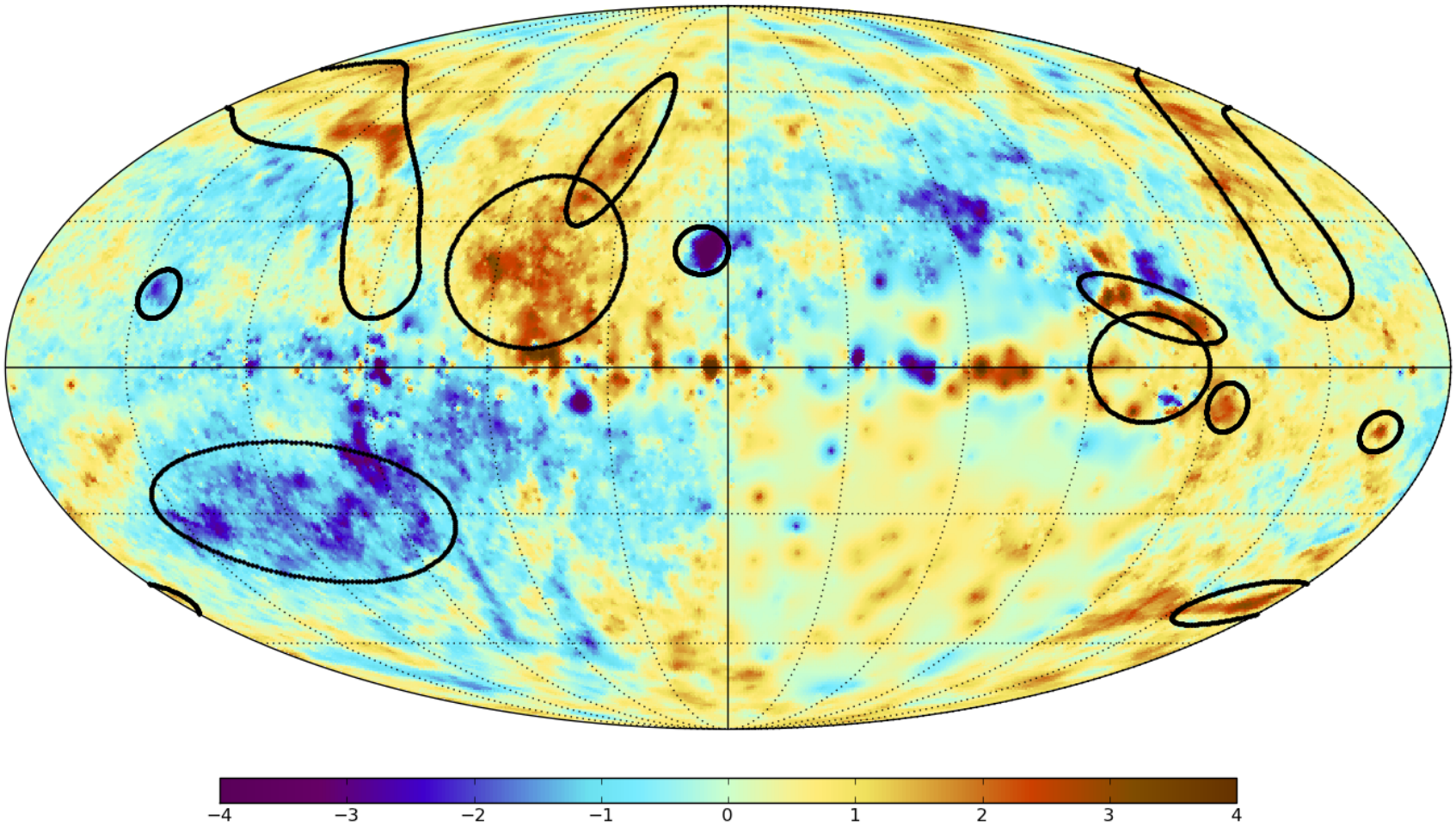
$$N_{ij} = \langle n_i n_j \rangle = \delta_{ij} \eta_i \sigma_i^2$$



Oppermann et al. 2011arXiv1111.6186O

Why it's useful


−4
−3
−2
−1
0
1
2
3
4


−4
−3
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0
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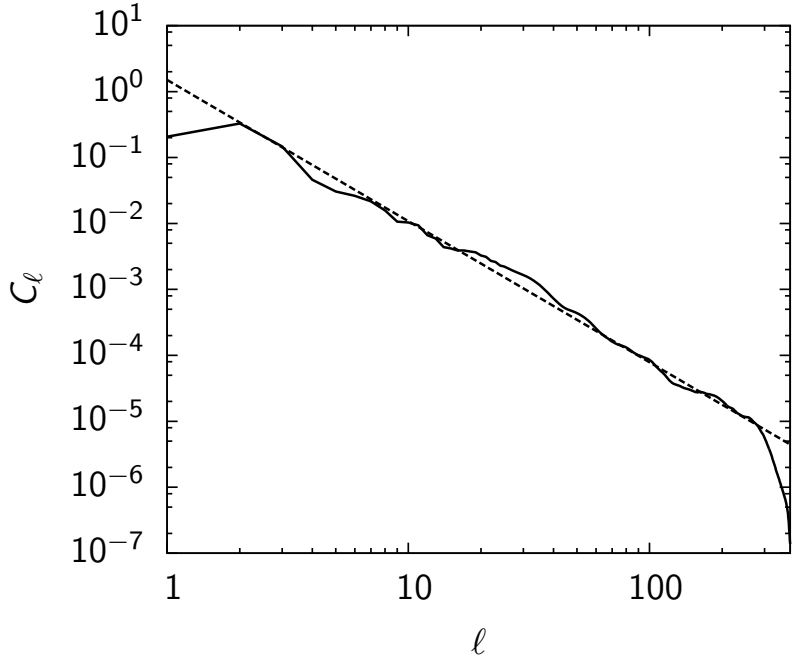
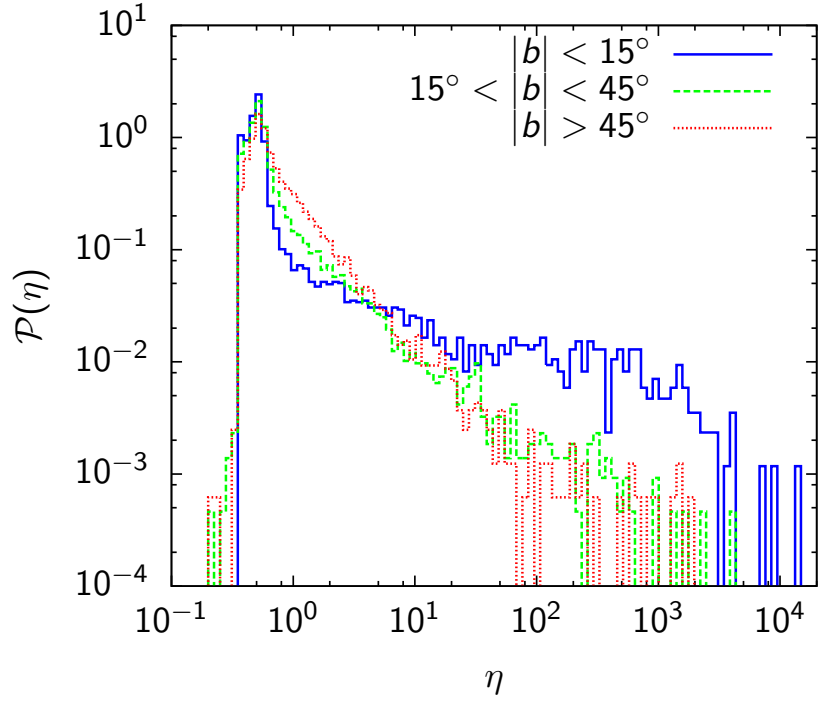
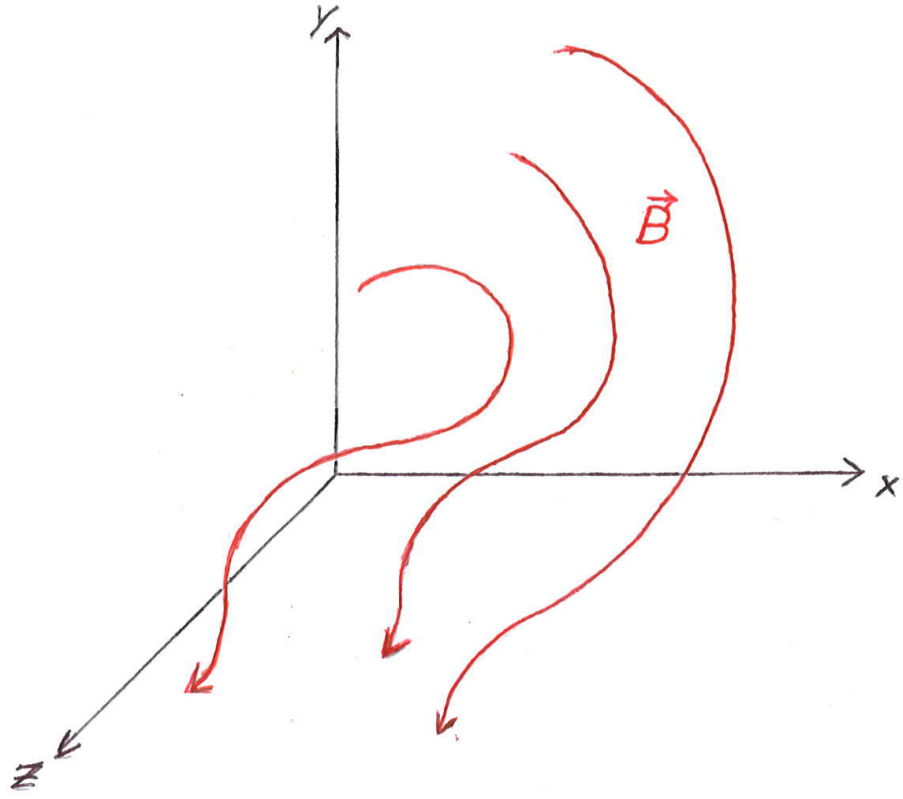
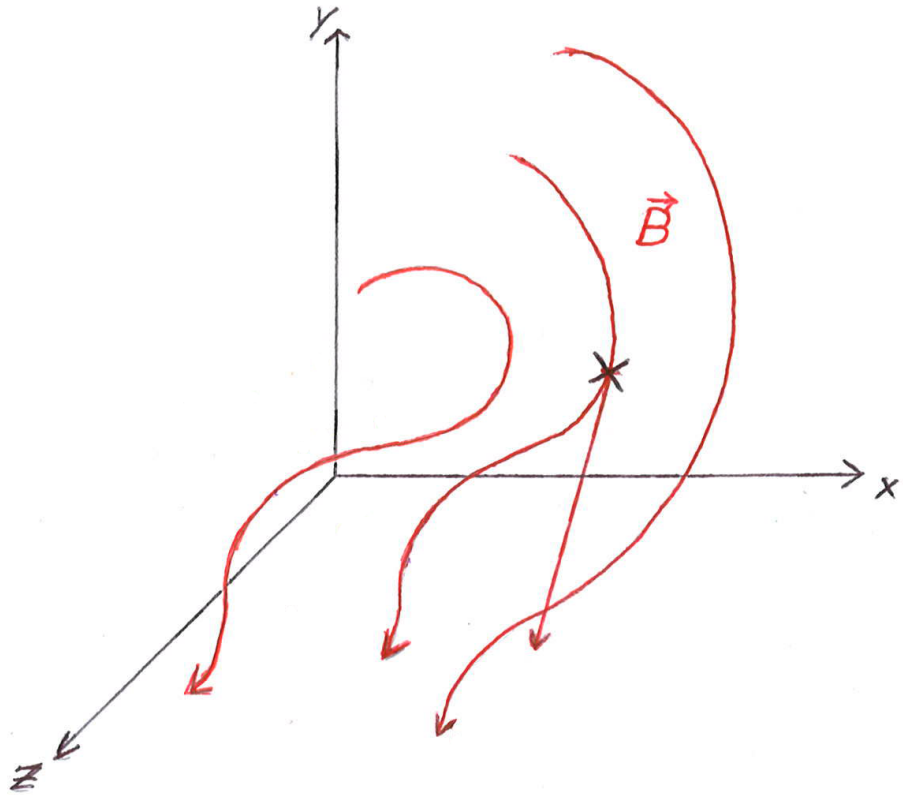


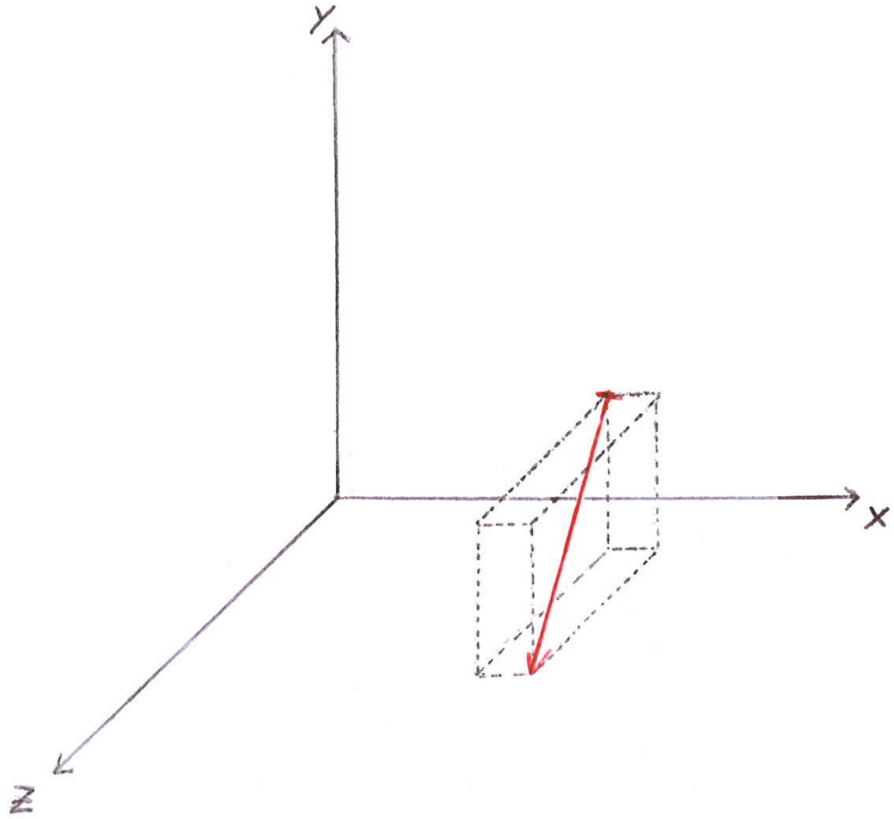
$$C_\ell \propto \ell^{-2.14}$$

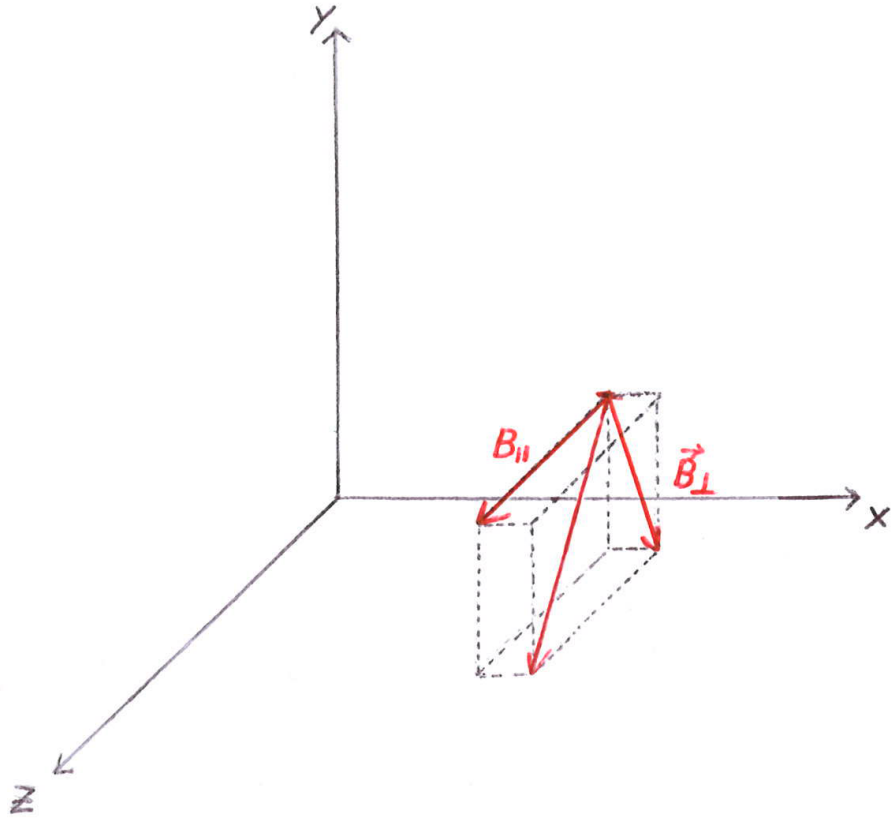


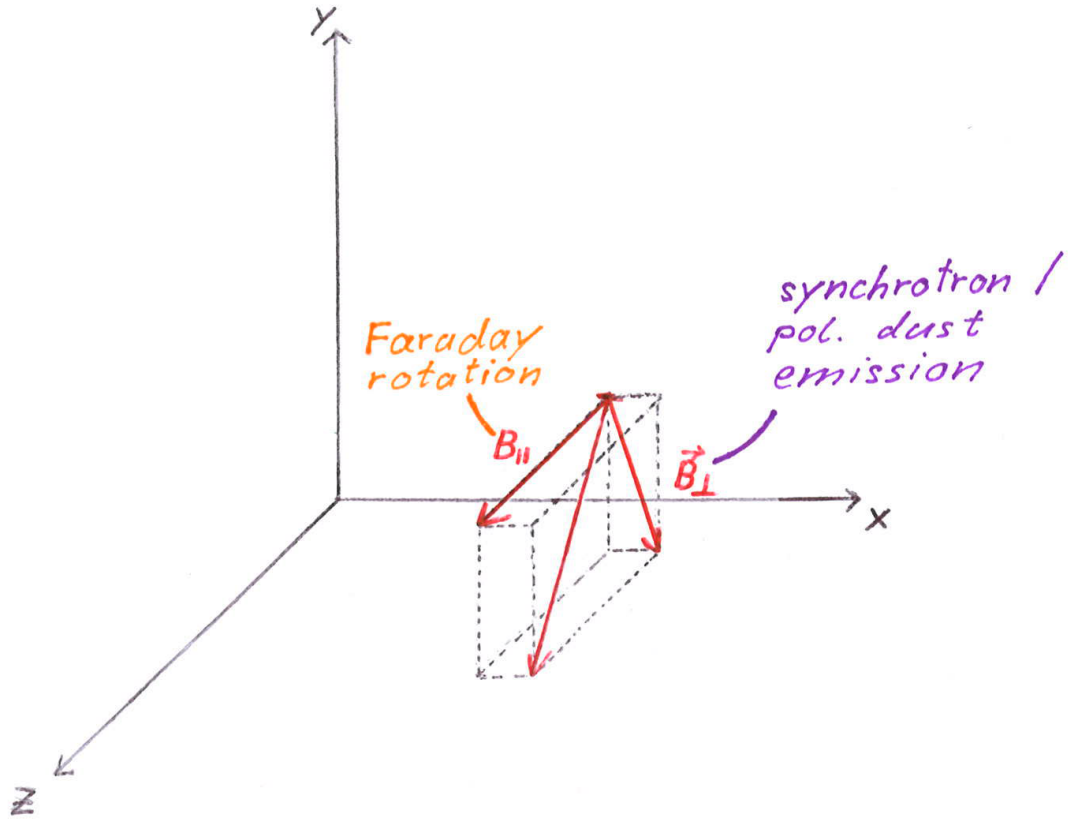
$$N_{ij} = \langle n_i n_j \rangle = \delta_{ij} \eta_i \sigma_i^2$$

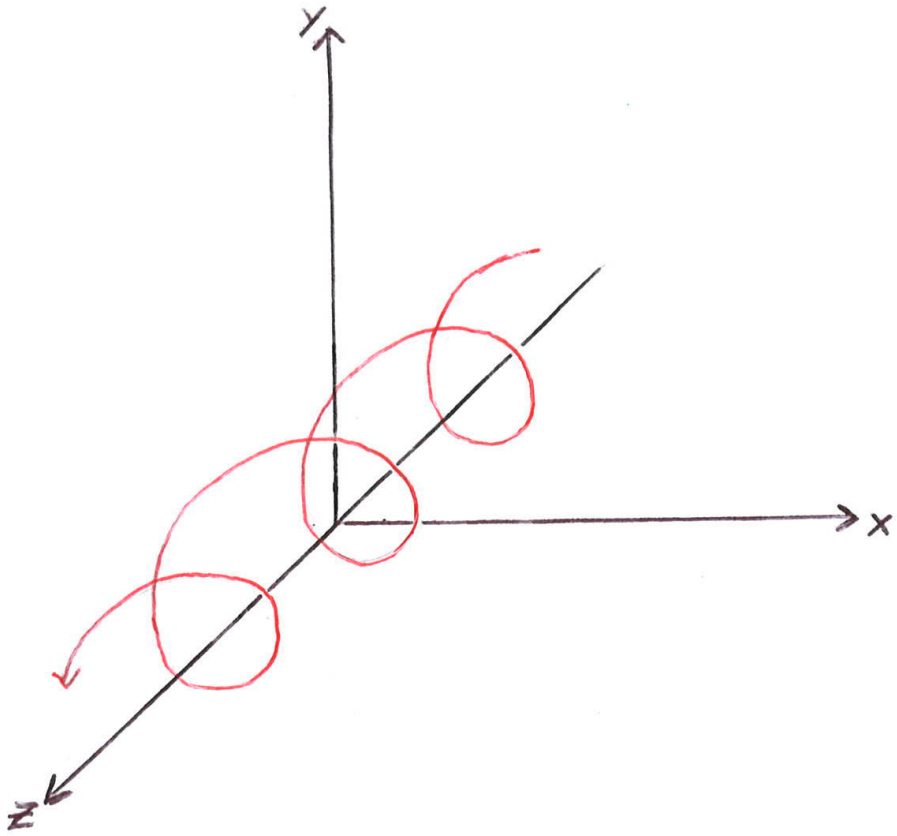

y
x
z
$\vec{B}$

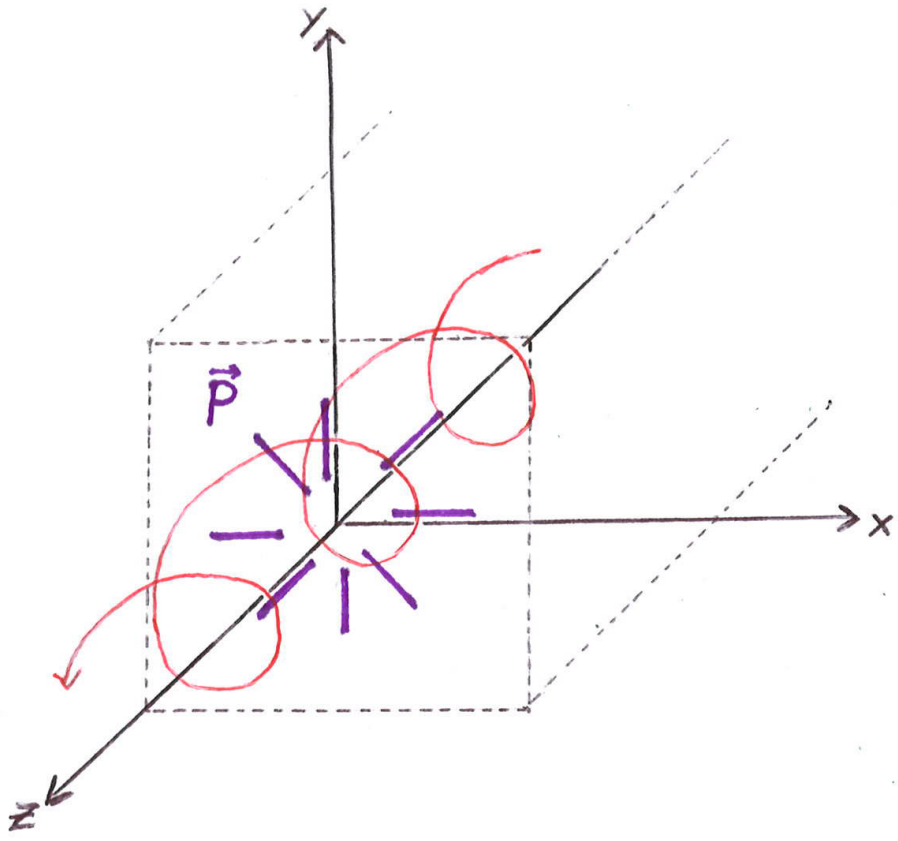

y
x
z
$\vec{B}$

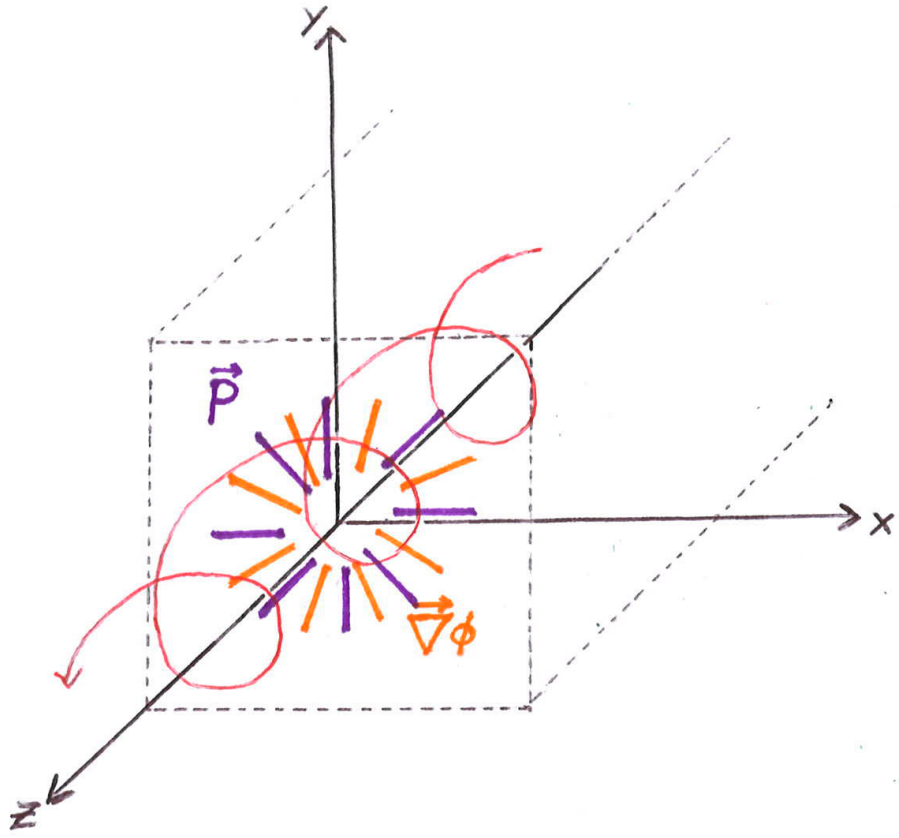

Y
X
Z


Y
X
Z
$B_{\parallel}$
$\vec{B}_{\perp}$


Y
X
Z
Faraday rotation
$B_{\parallel}$
synchrotron / pol. dust emission
$\vec{B}_{\perp}$


y
x
z

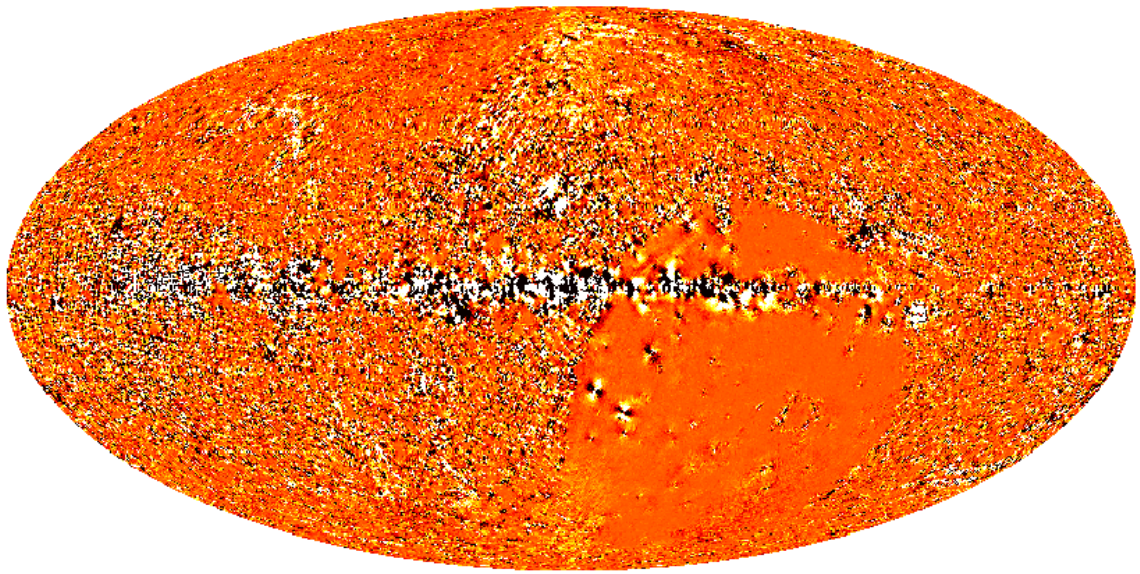

y
x
z
$\vec{P}$



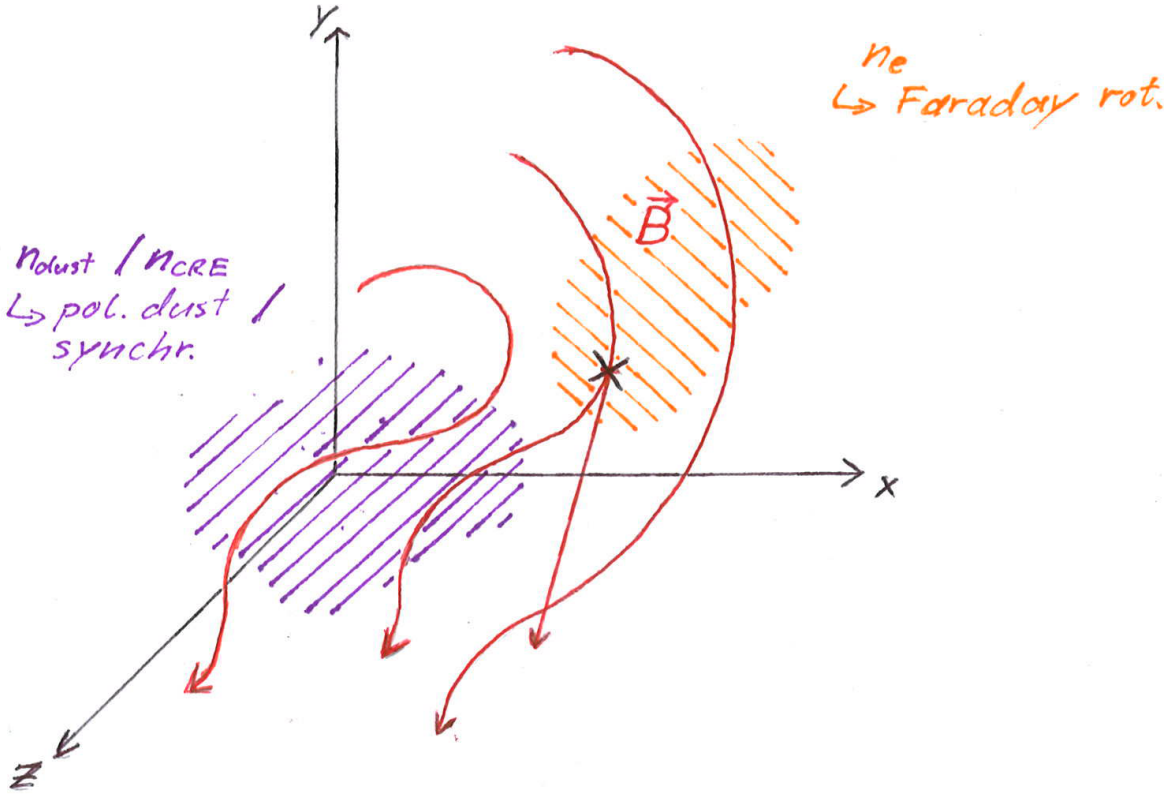
known as **LITMUS** procedure

Junklewitz et al. 2011A&A...530A..88J
Oppermann et al. 2011A&A...530A..89O

Alignment of $\vec{\nabla}\phi$ and $\vec{P}$



using WMAP 7yr K-Band polarization data (Jarosik et al. 2011ApJS..192...14J)


y
x
z
$\vec{B}$
n_e
↳ Faraday rot.
n_{dust} / n_{CRE}
↳ pol. dust / synchr.

Summary:

- New high-res. all-sky map of Galactic Faraday depth
  http://www.mpa-garching.mpg.de/ift/faraday/
- Extended Critical Filter deals with:
  - unknown signal covariance
  - incorrect errror information
- Science:
  - ISM-features
  - statistics
  - 3D $\vec{B}$-field information (helicity?)