Expected constraint on the Galactic magnetic field using PLANCK data

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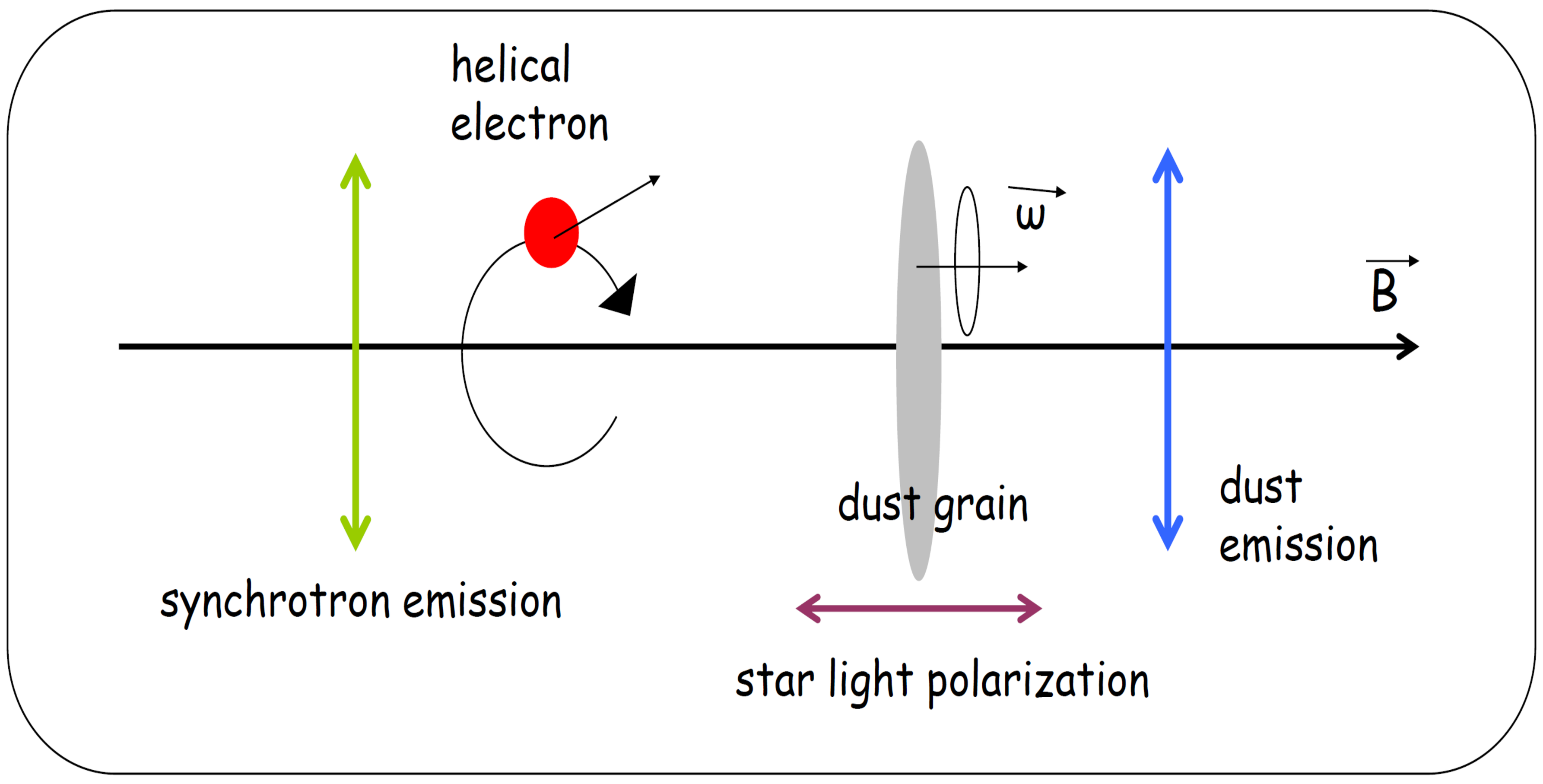
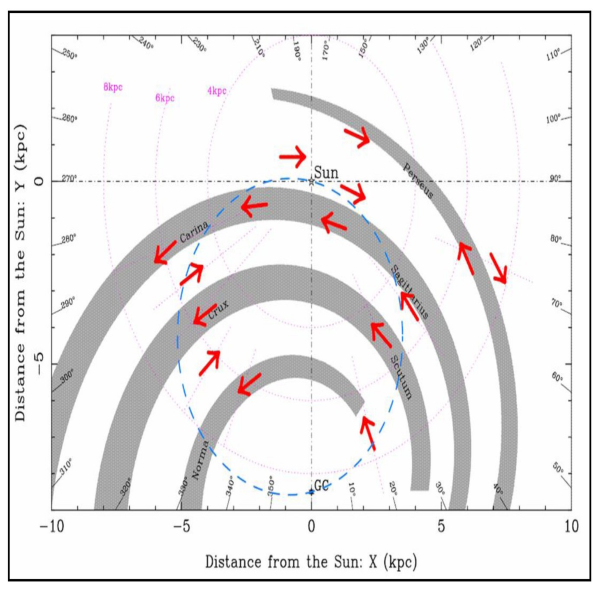
Physics of the foreground emissions



[Rybicki & Lightman, 1979] [Hoang & Lazarian, 2008]
[Fauvet et al, 2011]

3D modeling of the Galaxy

regular component : oriented along the spiral arms → it can be modeled by a *BSS* (Bisymetric Spiral)



$$B_{\log} = B_0 \cdot \Big[\cos(\phi+\beta) \ln\left(\frac{r}{r_0}\right) \sin(p) \cos(\chi(z)) \cdot \mathbf{u}_r - \cos(\phi+\beta) \ln\left(\frac{r}{r_0}\right) \cos(p) \cos(\chi(z)) \cdot \mathbf{u}_\phi + \sin(\chi(z)) \cdot \mathbf{u}_z \Big]$$

turbulent component 3D gaussian
[Han et al, 2004]

CR electrons distribution

$$n_e(r,z) = n_{0,e} \cdot \frac{e^{-\frac{r}{n_{e,r}}}}{\cosh(z/\mathrm{kpc})\cosh(z/n_{e,h})},$$

[Page et al, 2003]

Dust grain distribution

$$n_d = n_{0,d} \cdot \frac{e^{-\frac{r}{n_{d,r}}}}{\cosh^2(z/n_{d,h})},$$

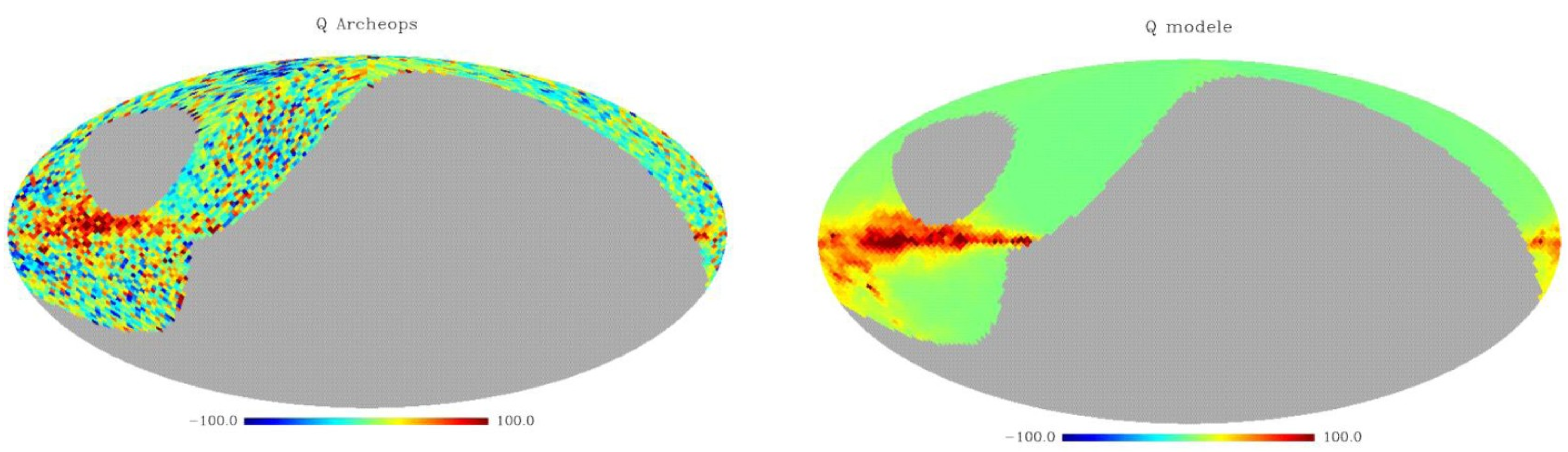
Thermal dust emission

- integrating along a line-of-sight

$$I_{md} = \int n_d \cdot ds$$
$$Q_{md} = \int dI \cos(2\gamma) \sin^2(\alpha) f_{\mathrm{norm}} p_d$$
$$U_{md} = \int dI \sin(2\gamma) \sin^2(\alpha) f_{\mathrm{norm}} p_d$$

$$\sin^2(\alpha) = \sqrt{\frac{1-B_l^2}{B_{\mathrm{norm}}}}$$

$$\gamma = \frac{1}{2}\arctan\left(\frac{2B_l \cdot B_t}{B_l^2 - B_t^2}\right)$$



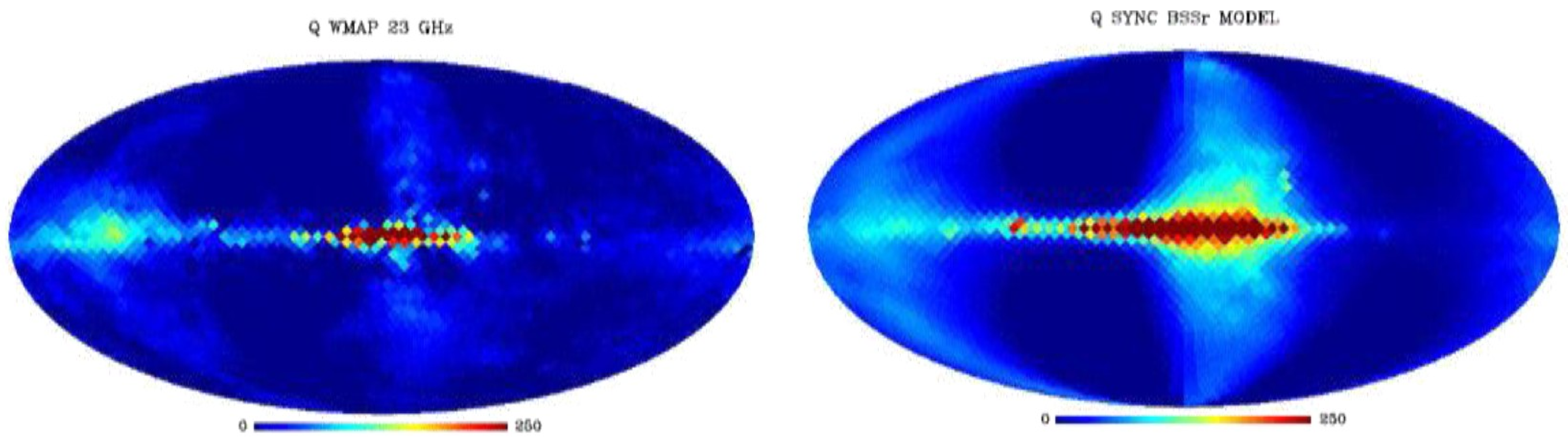
Synchrotron emission

- integrating along a line-of-sight

$$I = \int dI = \int n_e (B_l^2 + B_t^2)$$
$$Q_{ms} = \int dI \cos(2\gamma) p_s$$
$$U_{ms} = \int dI \sin(2\gamma) p_s$$

$$p_s = \frac{s+1}{s+7/3}$$ polarization fraction related to the slope of the energy distribution : s : $p_s = 0.75$

$$\gamma = \frac{1}{2}\arctan\left(\frac{2B_l \cdot B_t}{B_l^2 - B_t^2}\right)$$



Method of constraint

- simulations of Q and U maps for the PLANCK and WMAP 8-years data for each polarized channels :

$$\begin{pmatrix} Q^\nu \\ U^\nu \end{pmatrix} = \begin{pmatrix} Q^\nu_d \\ U^\nu_d \end{pmatrix} + \begin{pmatrix} Q^\nu_s \\ U^\nu_s \end{pmatrix} + \begin{pmatrix} Q^\nu_N \\ U^\nu_N \end{pmatrix} + \begin{pmatrix} Q^\nu_{CMB} \\ U^\nu_{CMB} \end{pmatrix}$$

- 4 kinds of simulations :
  -> with/without turbulent component of the magnetic field (A_{turb} = 0.25).
  -> spectral indices constants (β_s = -3.0, β_d = 1.4) or variables .

- noise : gaussian random noise simulations [Planck Bluebook, 2004]
- CMB : ΛCDM model [Komatsu et al, 2010]

→ constraint by Galactic profiles comparison model/simulation

Results

- simultaneous measurement of the synchrotron and thermal dust emissions properties.
- measurement of the regular magnetic field orientation at large scale (error < 5 degrees)
- accurate estimation of the turbulent magnetic field (error < 0,3 μG).
- measurement of $n_{e,r}$ (error < 1 kpc)
- spatial variation of the spectral index
  → no bias on the constraints
- if A_{turb} ≠0: bias on p and β_d but affect not the constraints on the other parameters.

[Fauvet et al, submitted to A&A, 2011]

Conclusions

Using Planck data :
Constraints on the regular Galactic magnetic field orientation
Constraints on the isotropic turbulent component intensity
Simultaneous constraints on the polarized emission properties
→ without use external data

Fauvet et al, 2011
Cho & Lazarian 2008
Han et al, 2004/ Han et al, 2006
Page et al, 2003