Multidimensional and inhomogeneity effects on scattering polarization in simple prominence models

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What kind of information do we get from scattering polarization in spectral lines?

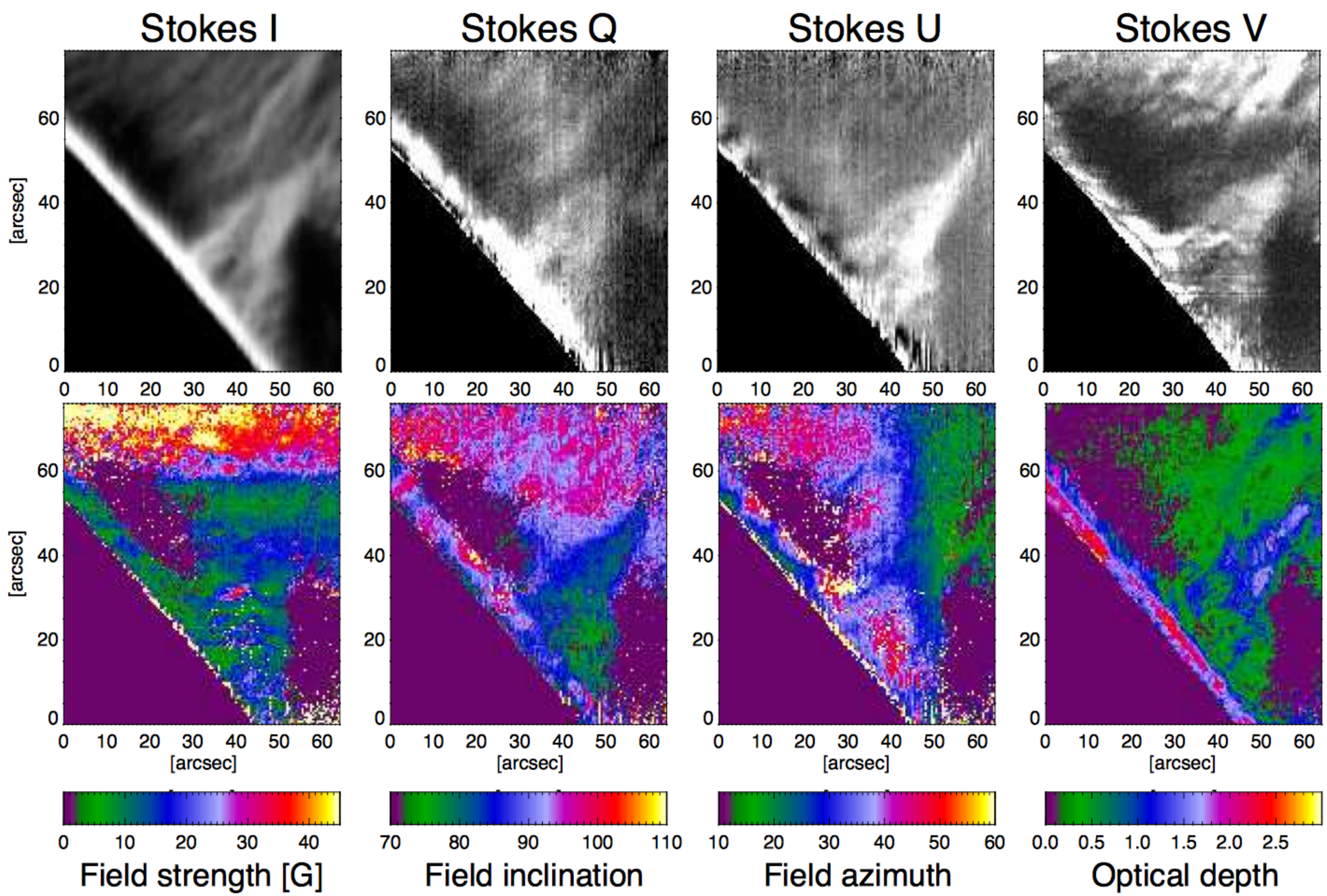
- We can probe geometry, that is (a)symmetry of the medium

- We can probe magnetic fields - Hanle effect.

- Sometimes the two must be treated simultaneously, in order to make proper diagnostics (i.e. using multidimensional radiative transfer to properly infer magnetic fields, like in Trujillo Bueno et al. 2004)

- **It is always interesting (and useful) to find out what do we miss on if we ignore some physical effects in the interpretation.**

Example where this might prove to be the case: Spectropolarimetry of solar prominences



Orozco Suarez, Asensio Ramos & Trujillo Bueno, 2014

Aim:

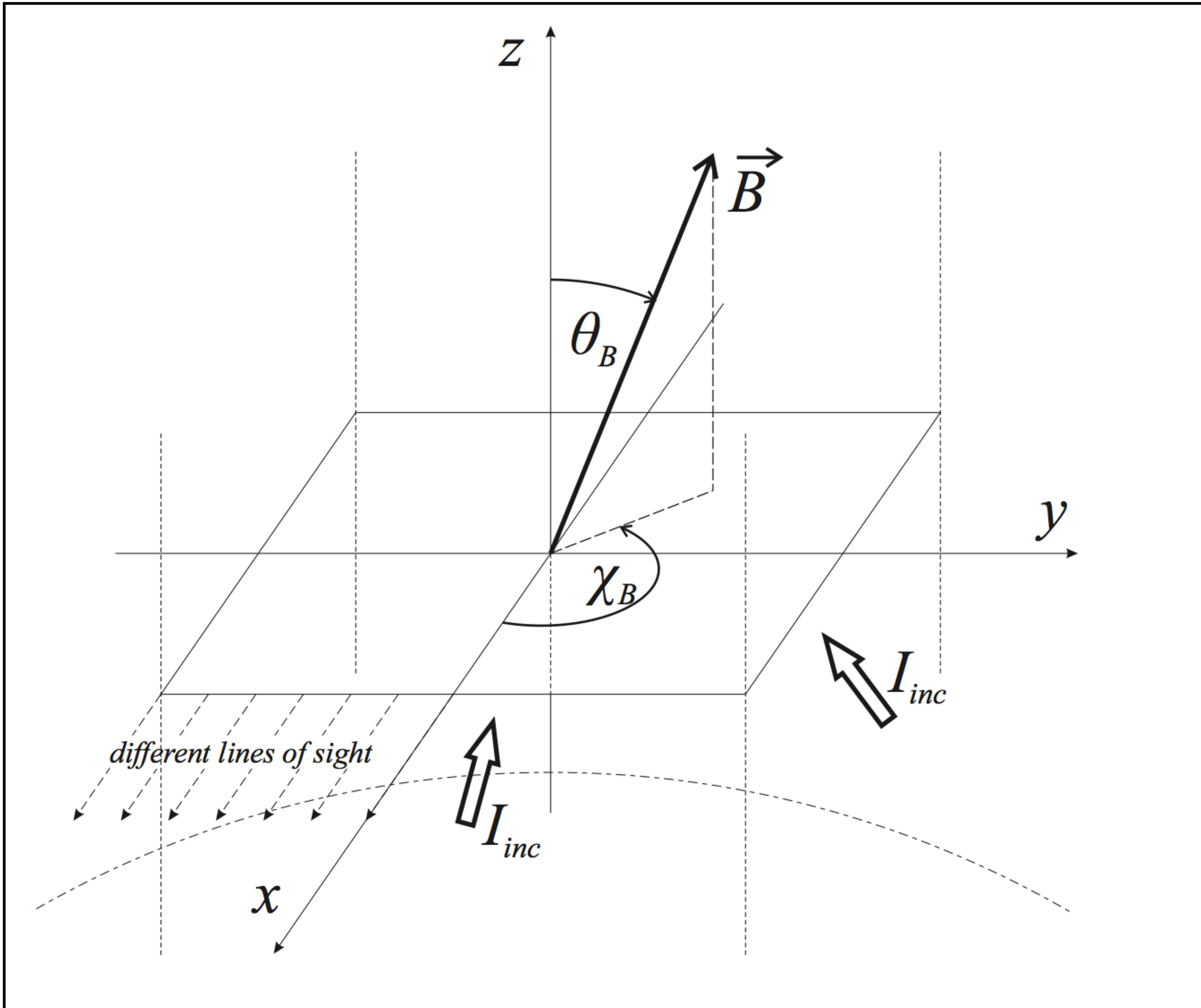
- Inversions like this one usually follow from fairly simple generative model (e.g. single scattering or 1D slab)
- Let’s investigate changes in emergent scattering polarization when more complicated model is introduced
- 2D (lateral) radiative transport
- Inhomogeneities
- Velocity fields
- **We make *ad hoc,* “toy” models and investigate the differences**

Method of solution:

- To obtain emergent Stokes vector we need to solve coupled equations of radiative transfer and statistical equilibrium. For simplicity, let us consider a two level atom model:

$$\frac{d\hat{\mathcal{I}}(x,y,\theta,\varphi,\nu)}{d\tau_\nu} = \hat{\mathcal{I}}(x,y,\theta,\varphi,\nu) - \hat{\mathcal{S}}(x,y)$$

$$\hat{\mathcal{S}}(x,y) = \epsilon\hat{\mathcal{B}}(x,y) + (1-\epsilon)\hat{W}(\vec{B})\times$$
$$\int \varphi(\nu)d\nu \oint \frac{d\hat{\Omega}}{4\pi}\hat{\Psi}(\theta,\varphi)\hat{\mathcal{I}}(x,y,\theta,\varphi,\nu)$$



z
$\vec{B}$
θ_B
y
χ_B
I_{inc}
different lines of sight
I_{inc}
x

Before playing around…

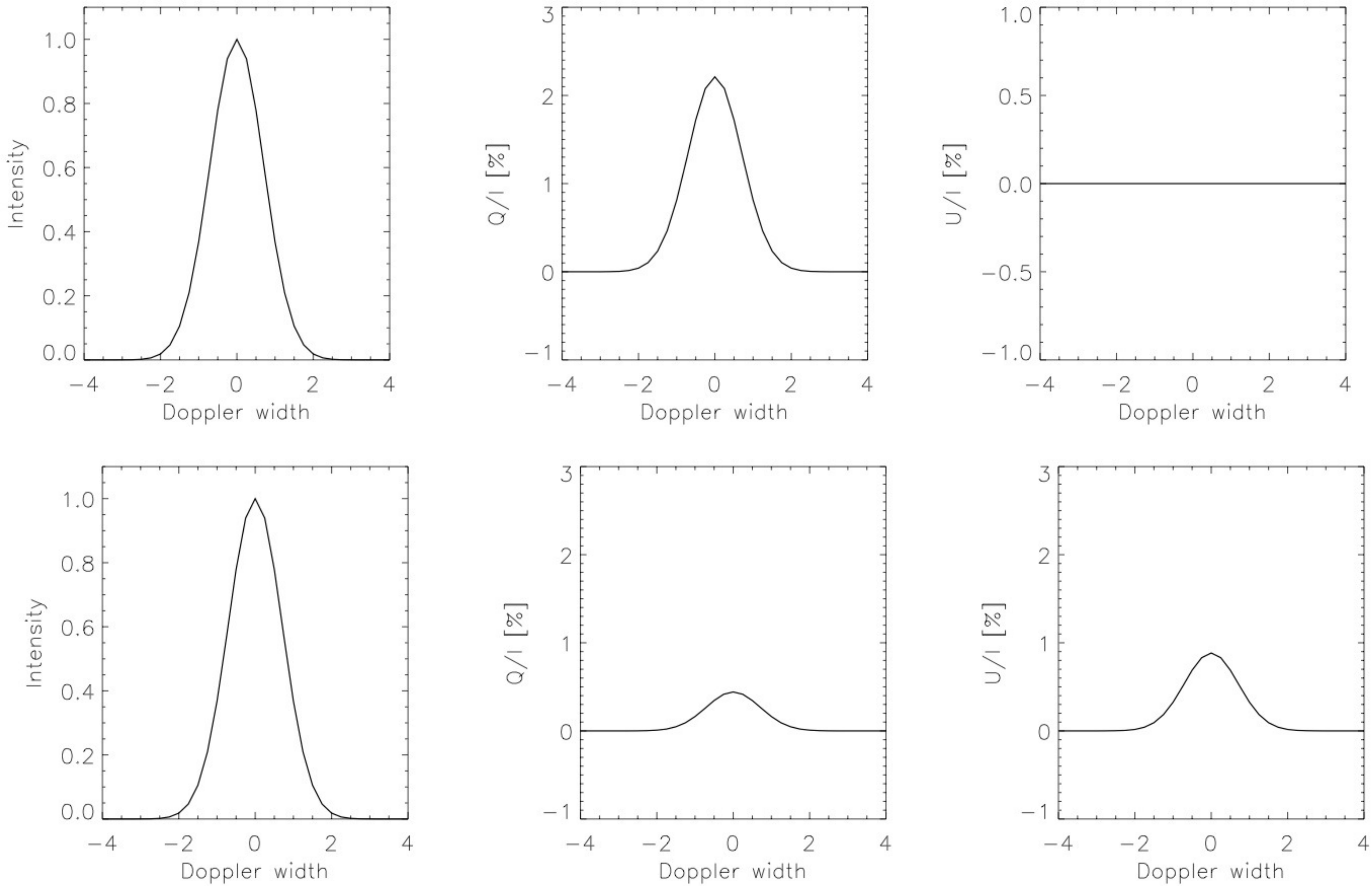
- **Let us discuss the geometric meaning of Stokes *Q* and *U* parameters:**

- Stokes *Q* probes vertical anisotropy of the radiation field (*if you illuminate the atom completely isotropically, there is no polarization)*

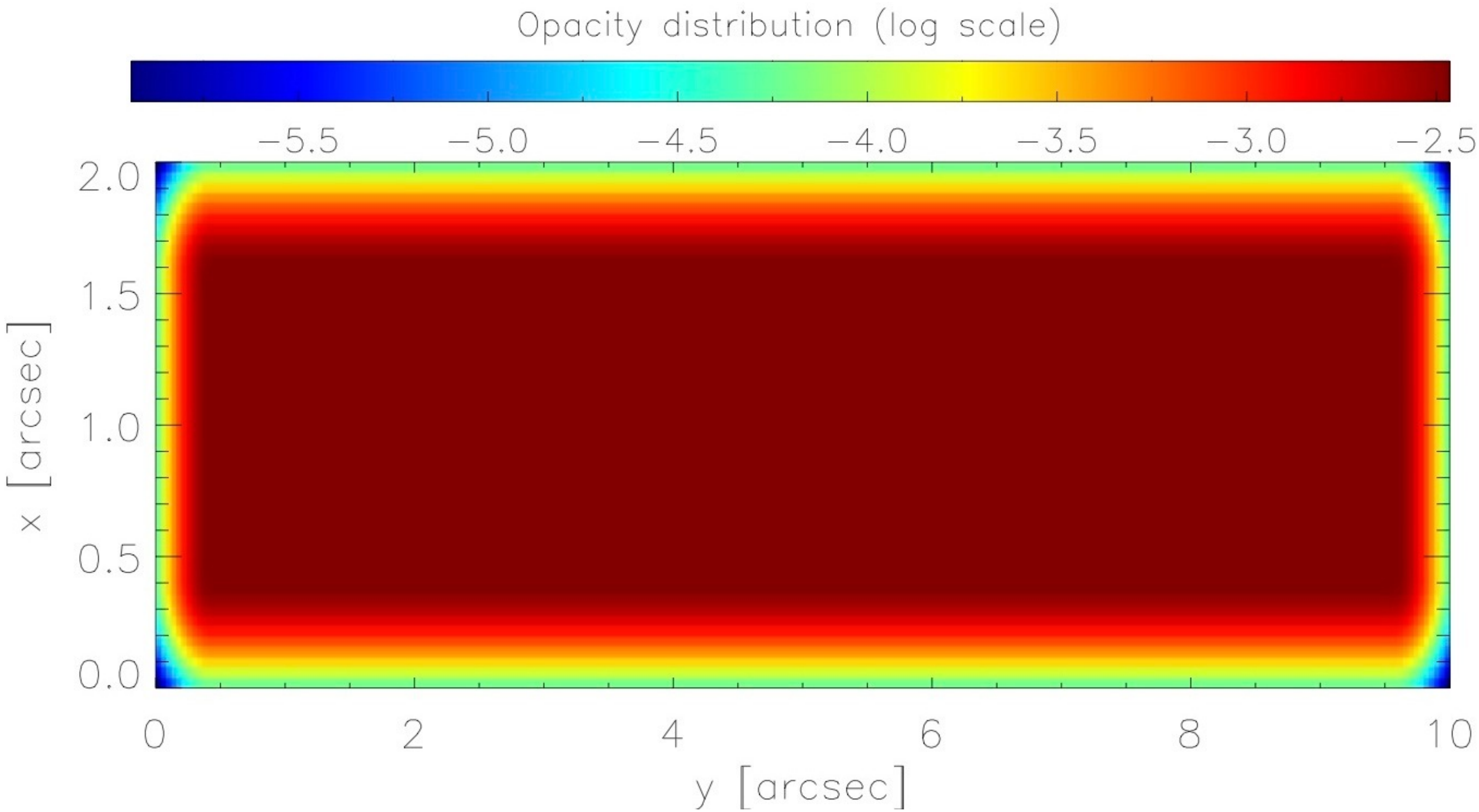
- In the similar way, Stokes *U* probes azimuthal anisotropy of the radiation field

- Large scale, oriented magnetic field couples the two. (*This is why you can diagnose vector magnetic fields via Hanle effect).*

The simplest case - single scattering



A simple 2D homogeneous slab



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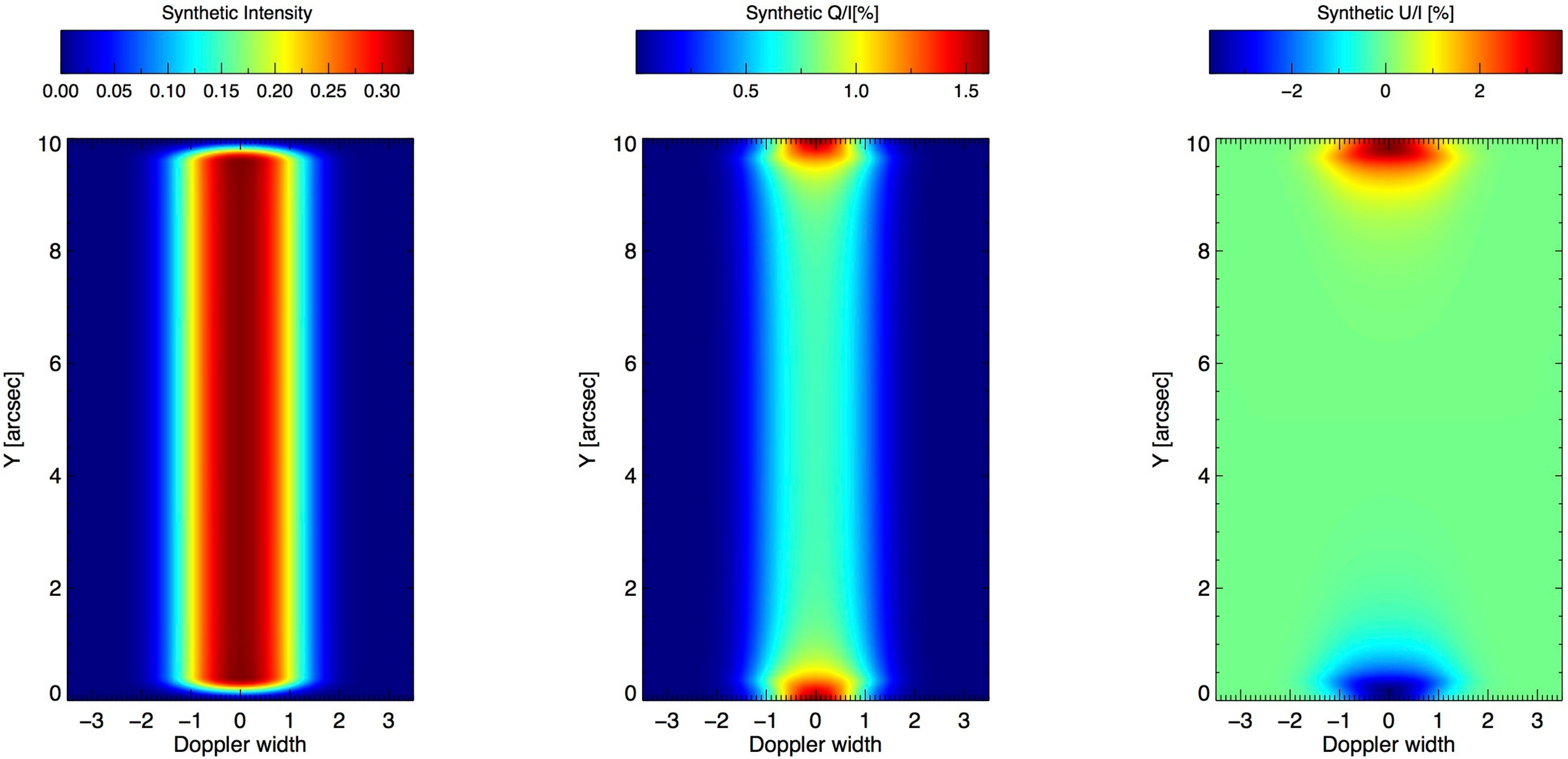
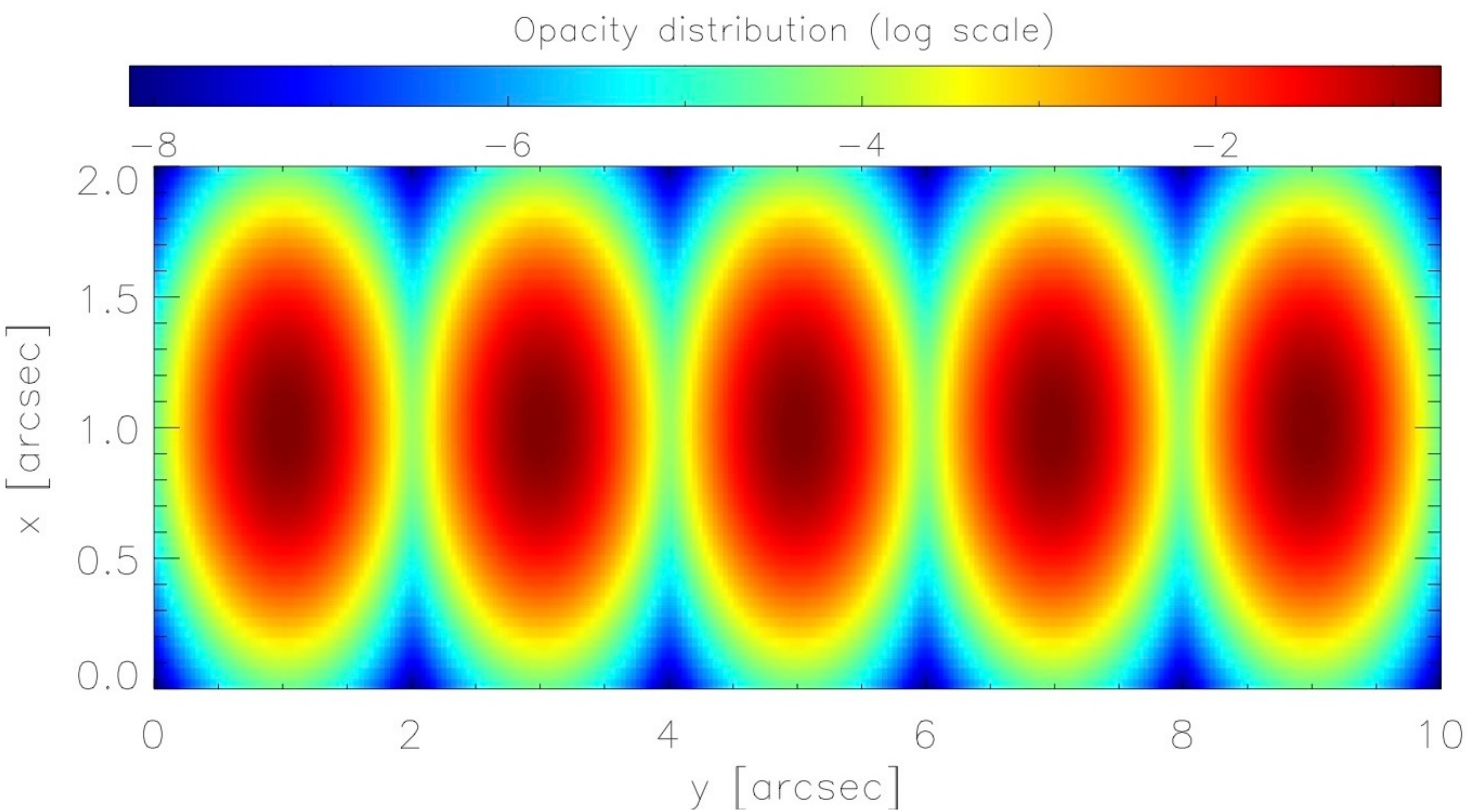


More complicated structure?



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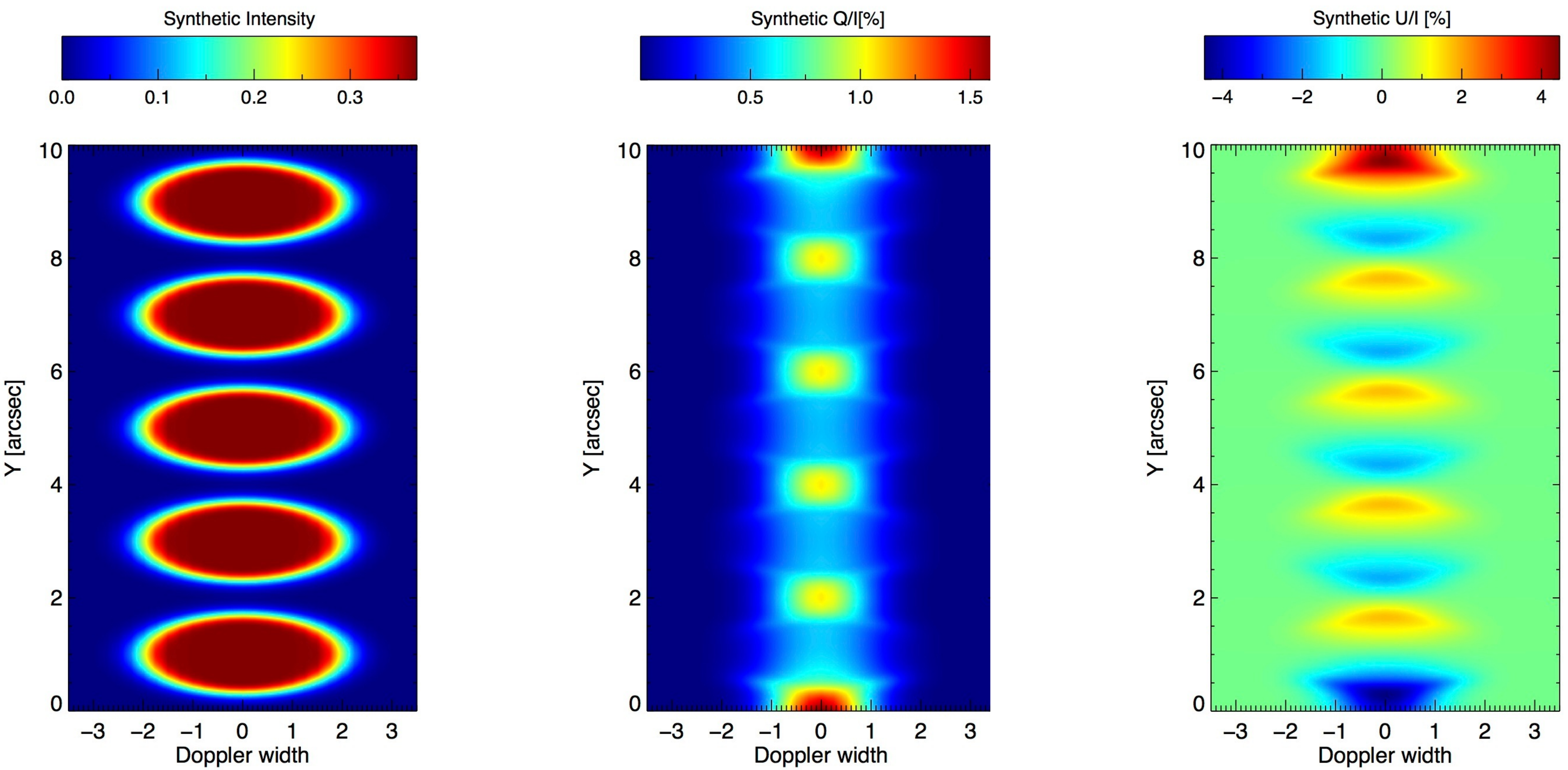
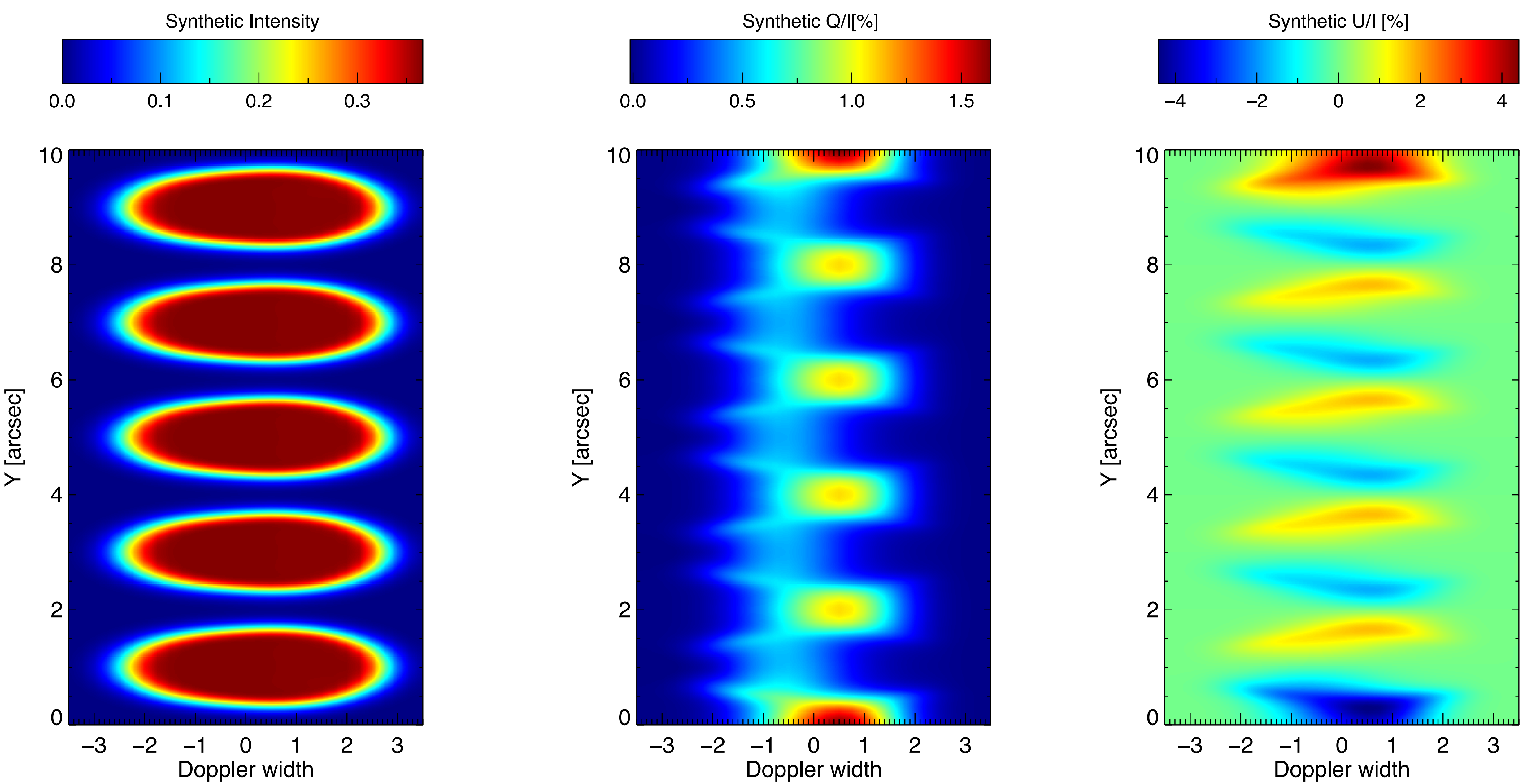


We can also add some velocity fields…

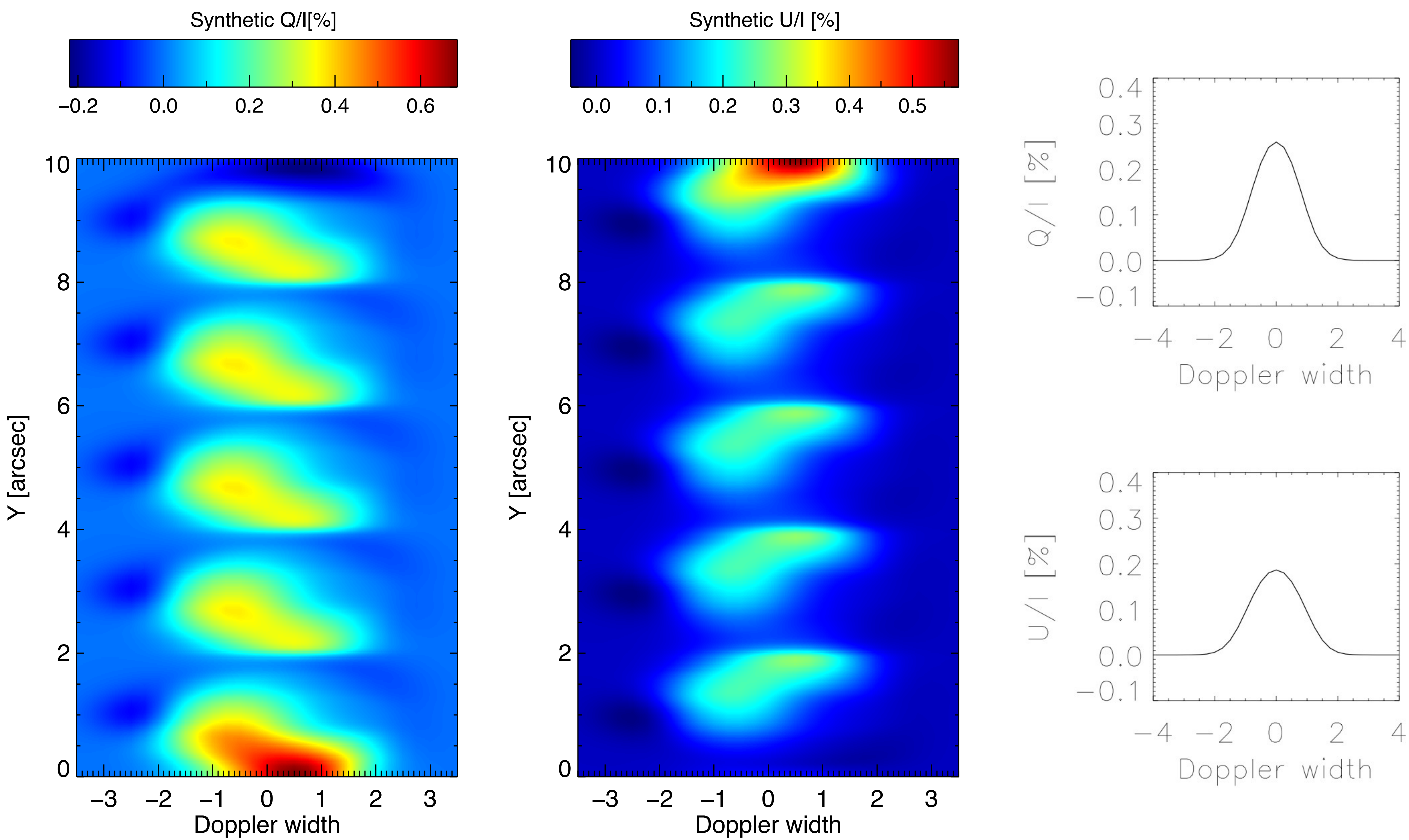
- It is well known now that prominences exhibit oscillations. So let us add a longitudinal standing way which looks like this:

$$v_x = \cos(4\pi x/x_{\text{total}})$$

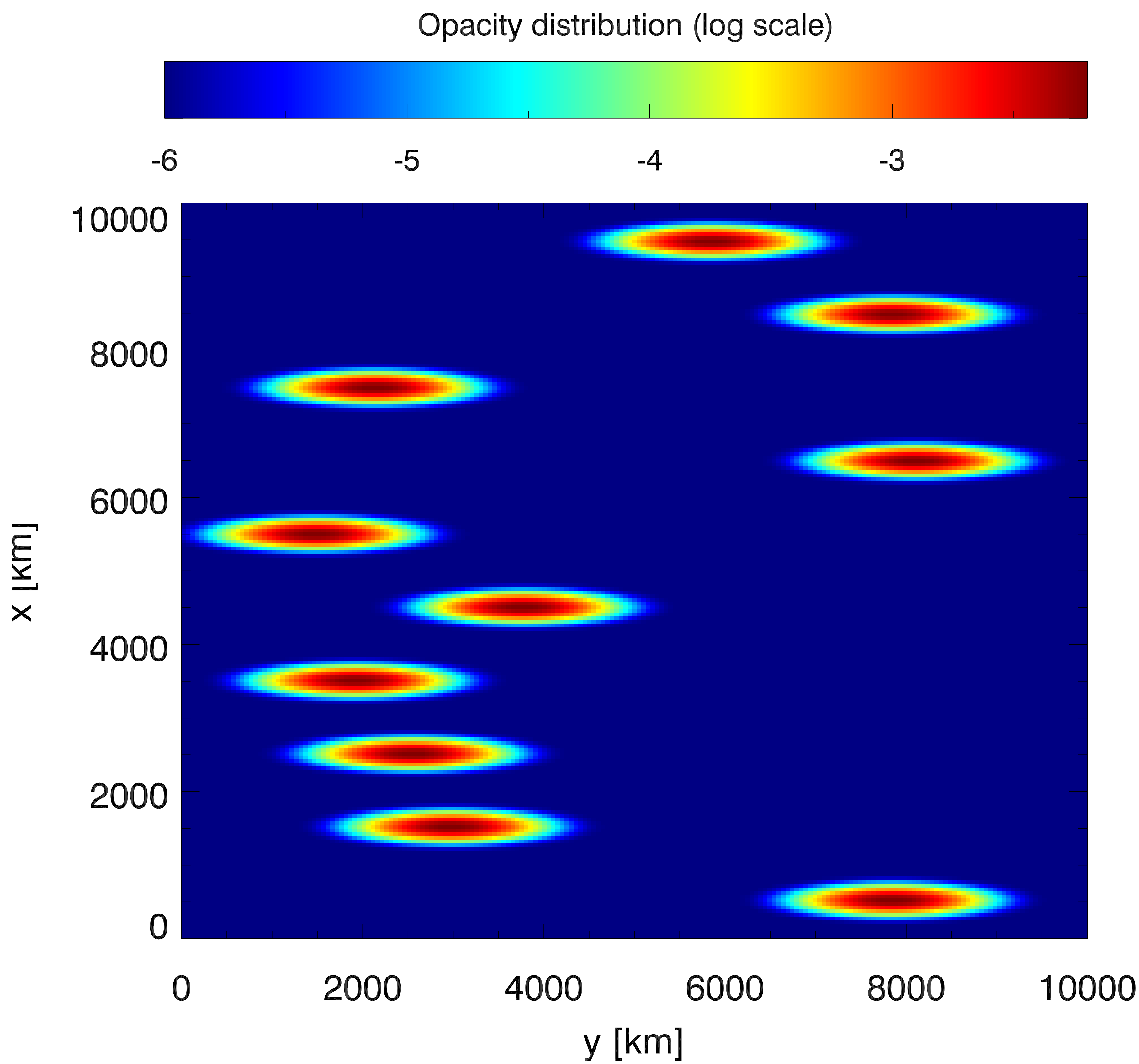


And, of course, the magnetic field!

$$\Gamma_H = 3;\ \theta_B = 80^o;\ \chi_B = 30^o$$



We have also tried to make a simplified version of the multithread model of Gunar et al.



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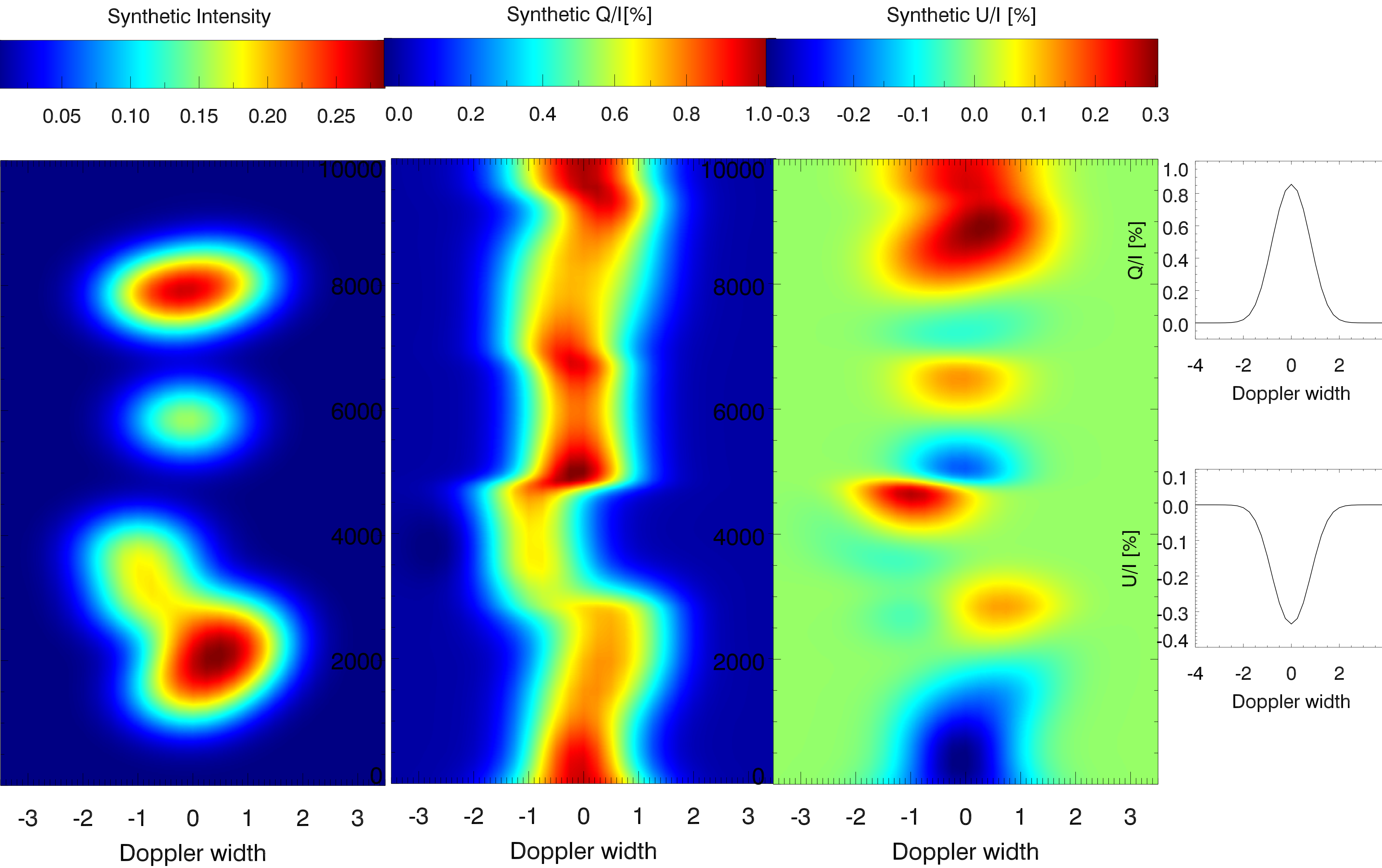
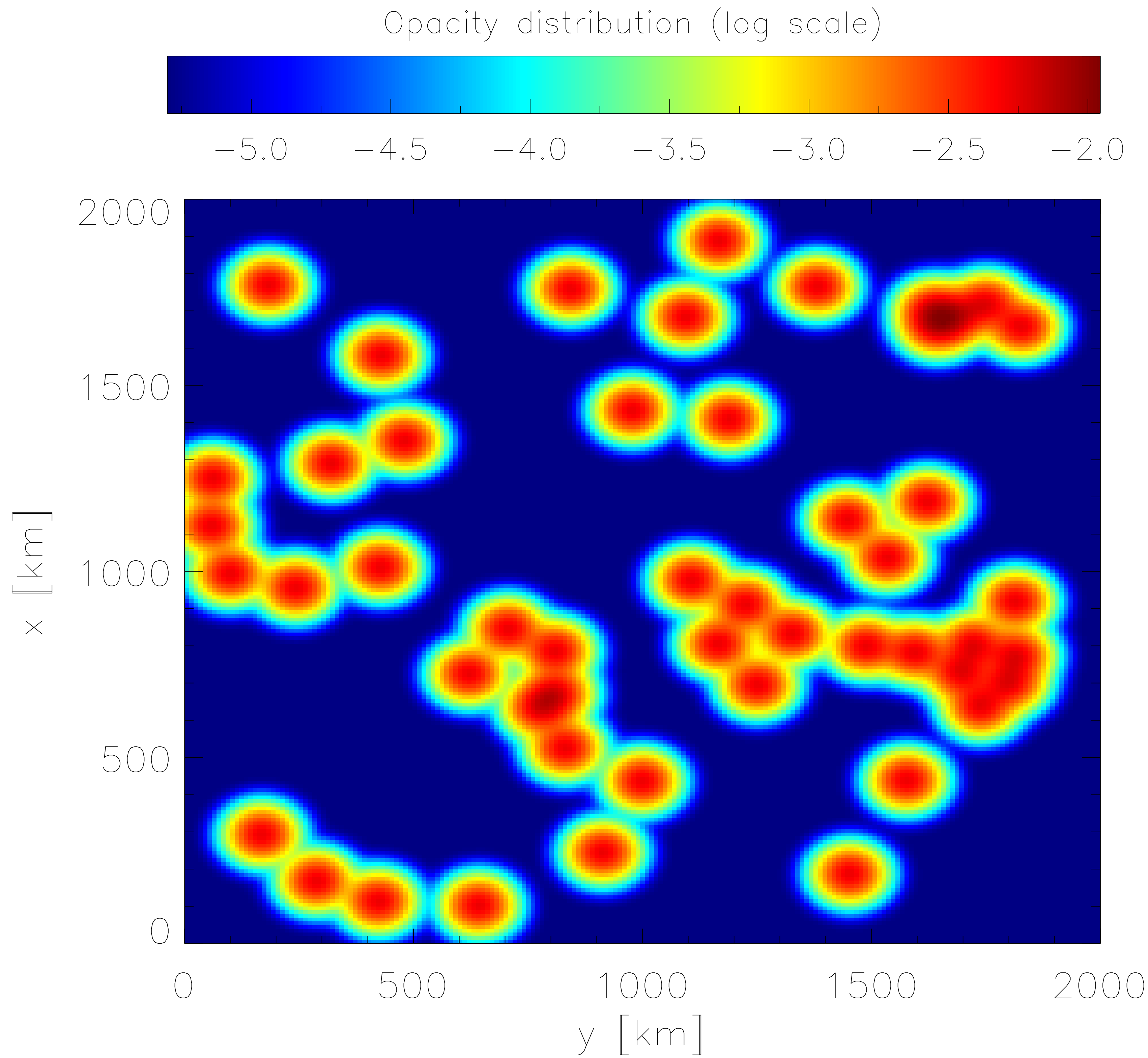


Let us see what happens if we make a random distribution of small threads (~50km wide)



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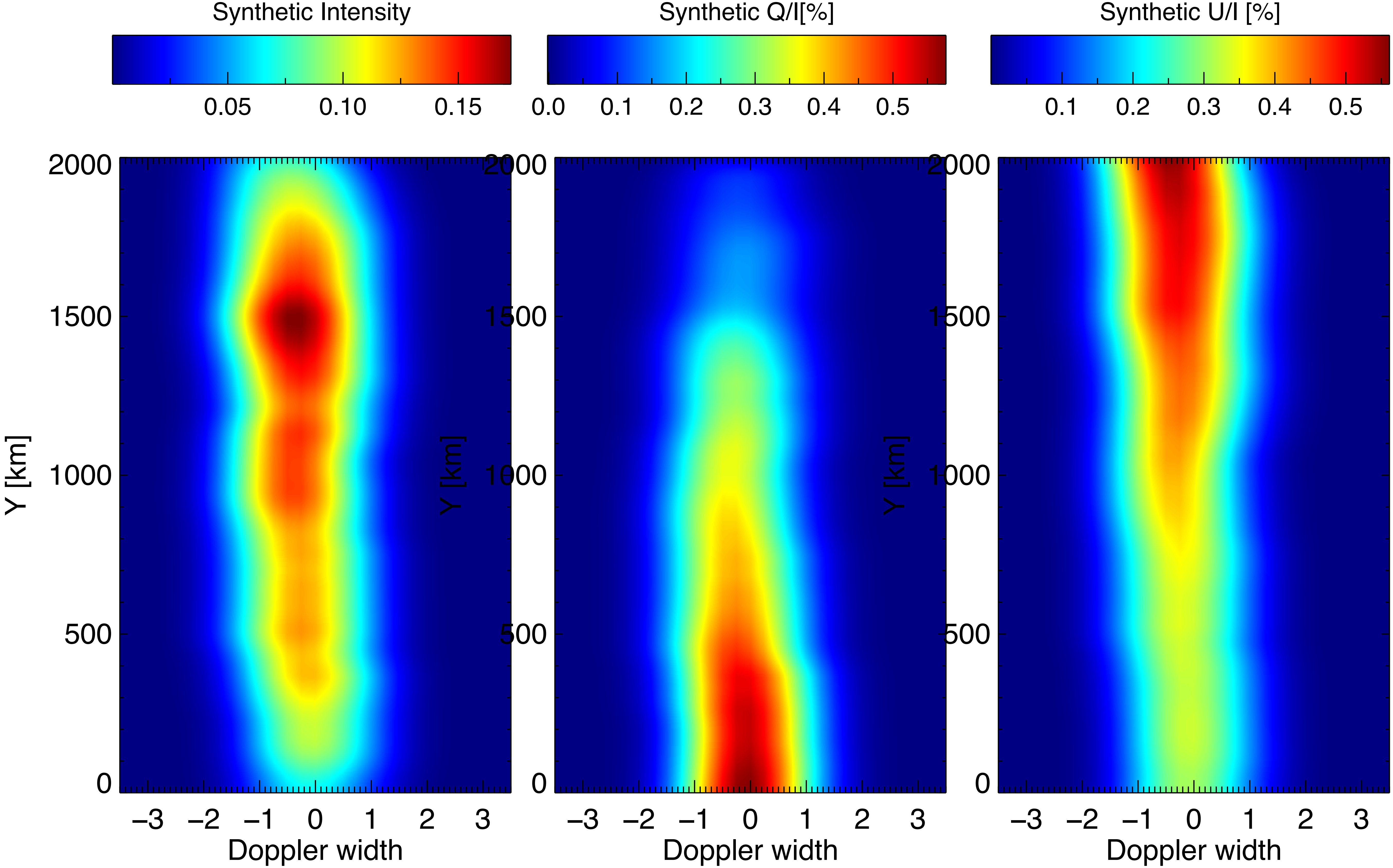

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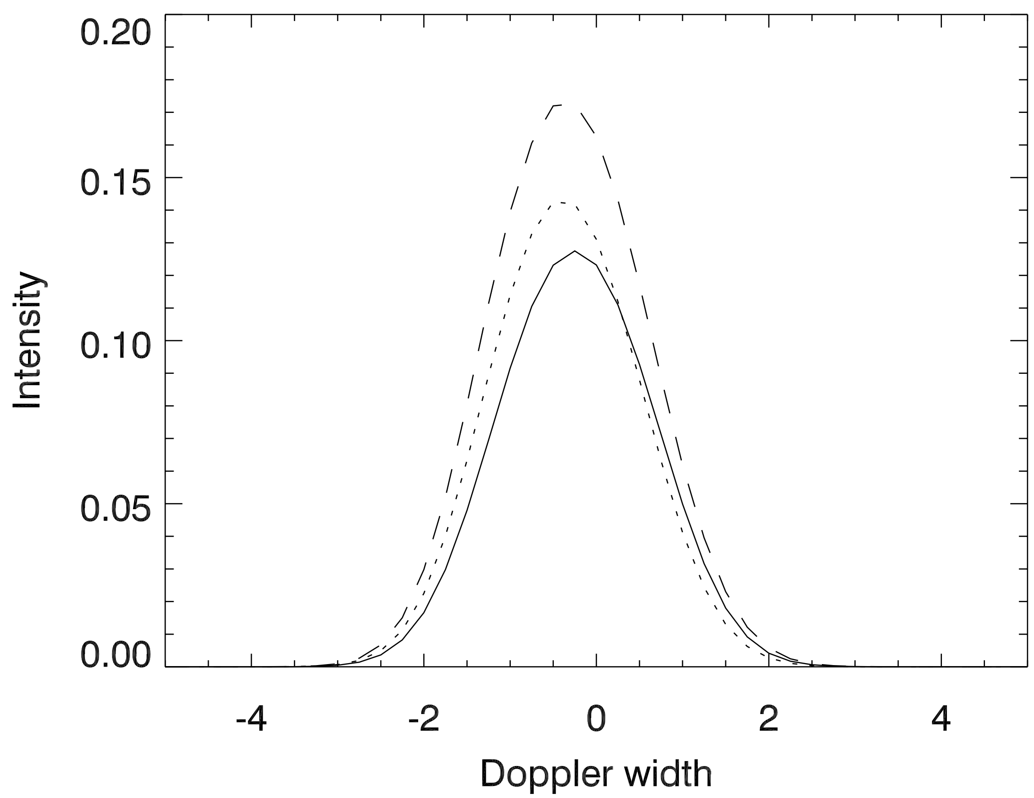

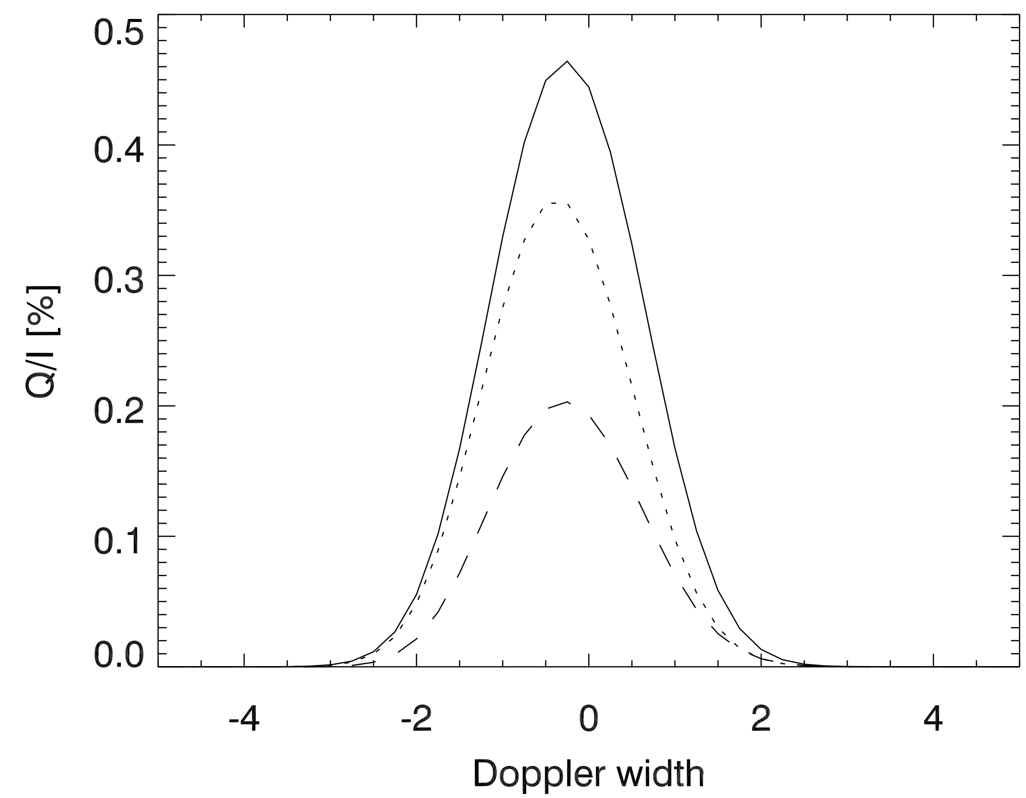

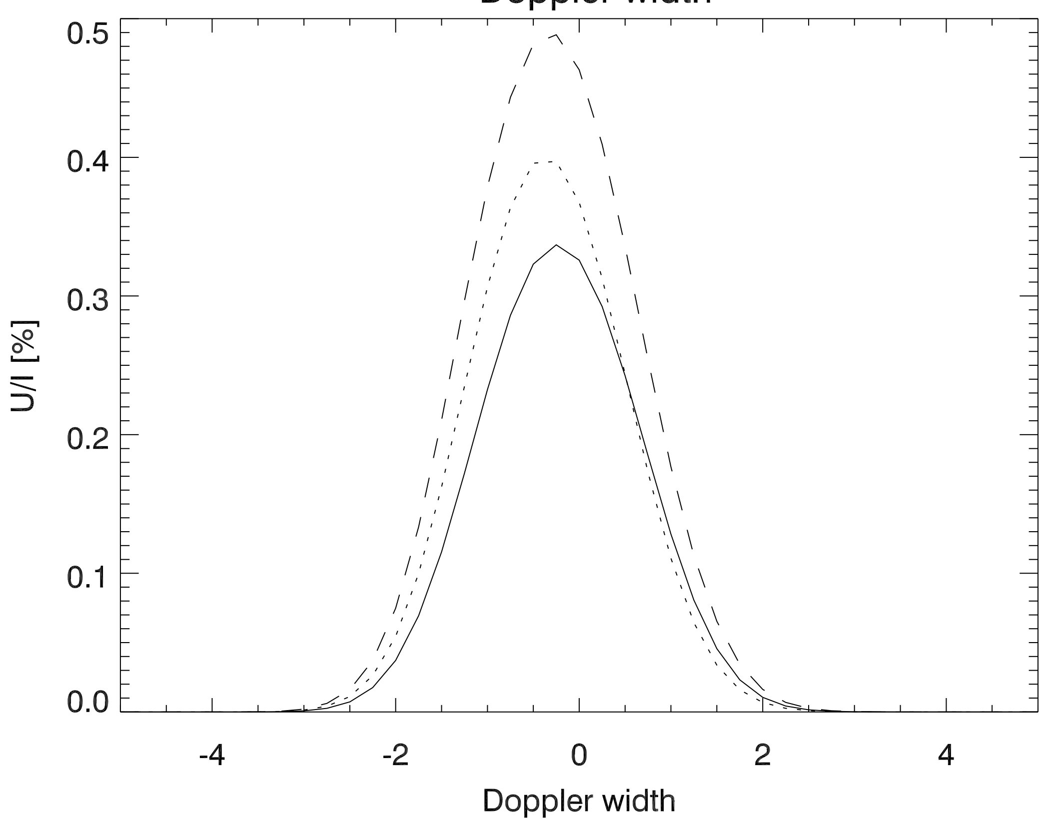

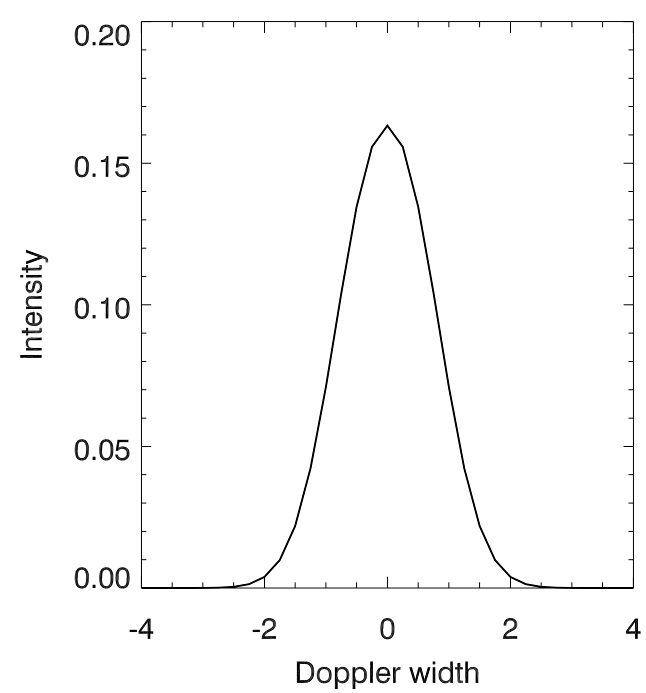

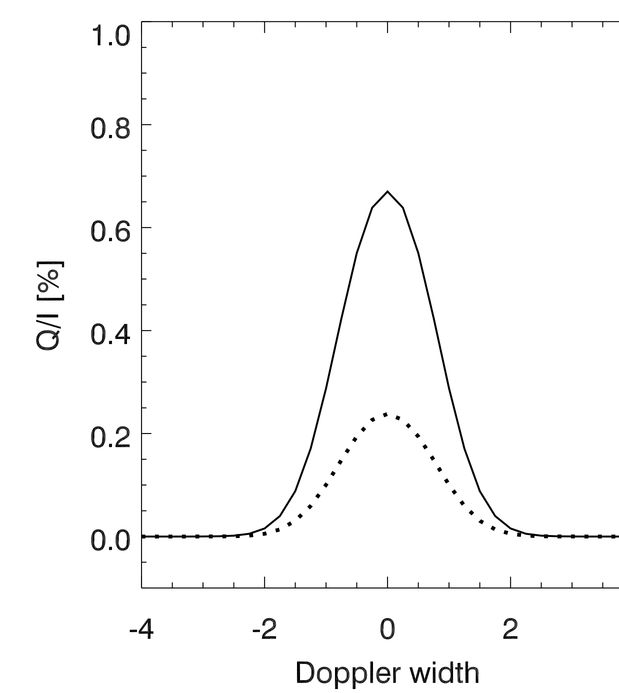

What can we conclude from these very simple examples?

- Inhomogeneity changes scattering polarization and its distribution

- In principle, modification of *Q* and *U* due to **non-magnetic effects** could lead to mis-diagnosis of the magnetic field (*set-up inversion and try!*)

- Could this be important for “real” lines?

- Next steps?