Inhomogeneity and velocity fields effects on scattering polarization in solar prominences

Ivan Milić (MPS) and Marianne Faurobert (OCA)
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 diagnostics (i.e. Hanle diagnostics of solar magnetic fields using multidimensional polarized RT, e.g. Trujillo Bueno et al. 2004)

• It is always interesting (and hopefully useful) to study the interplay of the two
Context:

- When we interpret (fit, invert) the observations we usually use a simple generative model (1D)

- 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, investigate the differences with respect to 1D and attempt some simple fitting
A numerical experiment:

• Consider a two-level atom model (atomic parameters correspond to red component He10830)

• Make an inhomogeneous slab, pervade it with magnetic field, illuminate it with limb-darkened radiation, and see what comes out.

• Compare with 1D

• Are there differences?

Orozco Suarez et al. 2014
Before experimenting...

- **Remember:**

  - 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

  - Magnetic field couples the two
The simplest case - single scattering
A simple 2D homogeneous slab
Randomly distributed “clumps” with random velocities

Opacity distribution (log scale)

Synthetic Intensity

Synthetic Q/I [%]

Synthetic U/I [%]
And then, add very weak magnetic field

\[ B = 1G, \theta_B = 30^\circ, \phi_B = 150^\circ \]

\[ B = 0.7G, \theta_B = 37^\circ, \phi_B = 135^\circ \]
And then, add a very weak magnetic field

\[ B = 1G, \theta_B = 30^\circ, \phi_B = 150^\circ \]

\[ B = 1G, \theta_B = 45^\circ, \phi_B = 145^\circ \]
With stronger magnetic field

\[ B = 10G, \theta_B = 30^\circ, \phi_B = 150^\circ \]

\[ B = 8G, \theta_B = 60^\circ, \phi_B = 163^\circ \]
With more threads...

Opacity distribution (log scale)

Synthetic Intensity

Synthetic Q/I [%]

Synthetic U/I [%]
What can we conclude from these simple examples?

- Multidimensional RT effects can have a significant effect on polarization even in plasma which is *almost optically thin*.

- Can it be important in “real life” cases?

- In other objects: filaments, flares *(take a look @ Stepan & Heinzel, 2013)*…

- If it is important, how to handle it?