Poynting flux derived from photospheric motions

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Table of Contents

Photometry

Brightness is over 9000...

Figure 1: Idea of photometry

Spectroscopy

Shiny stuff...

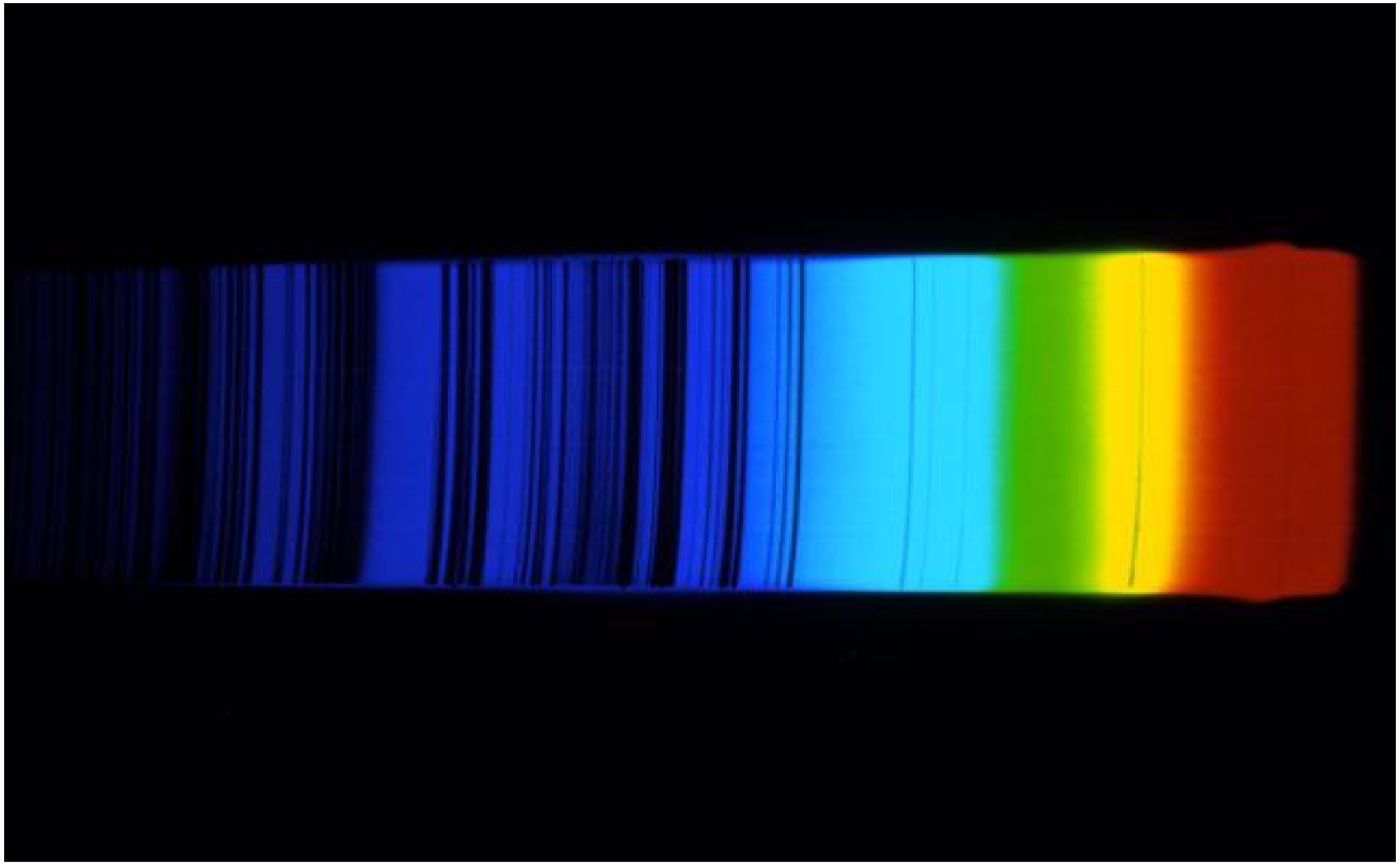


Figure 2: Idea of spectroscopy

Polarimetry

It wiggles so its cool..

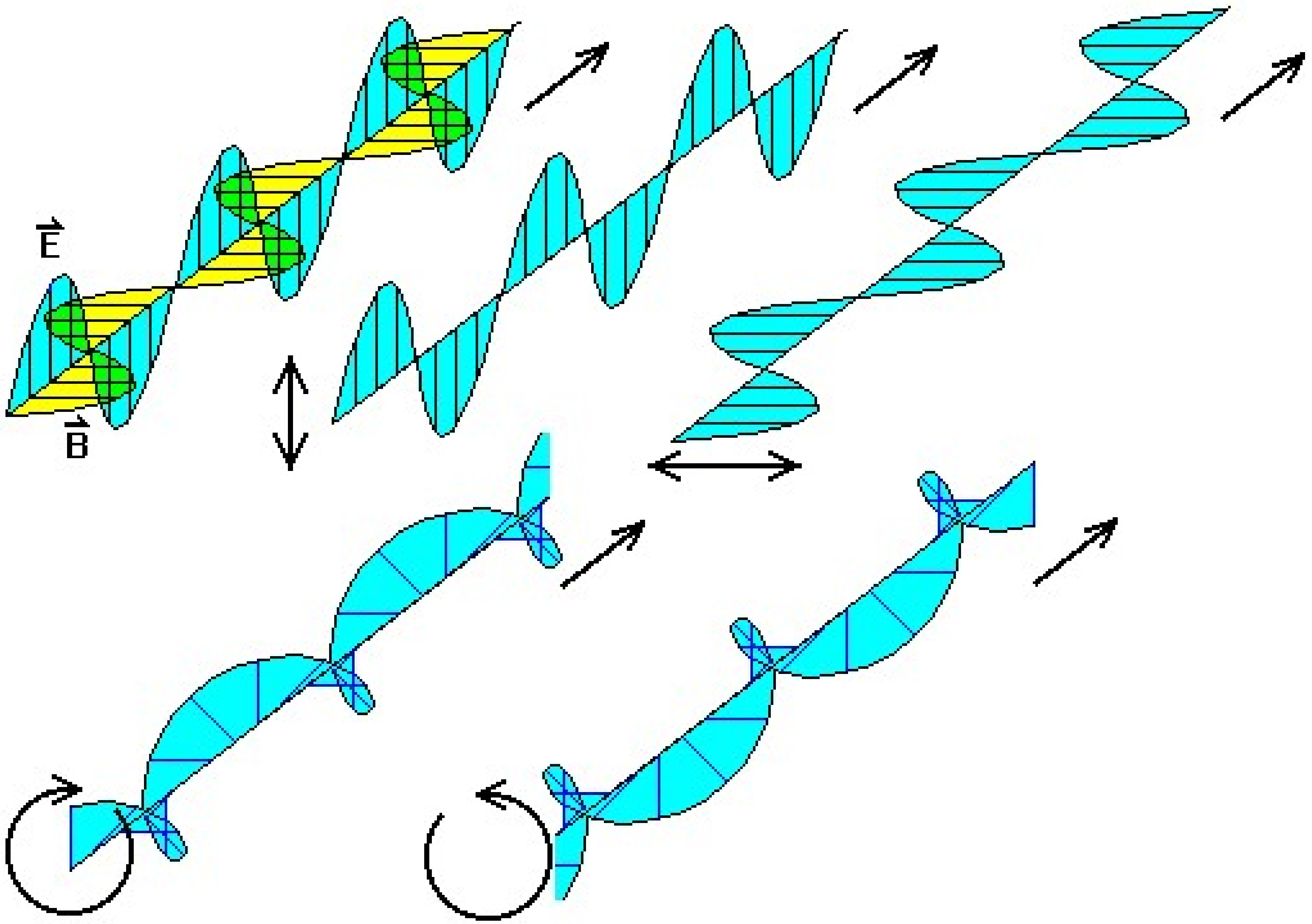


Figure 3: Idea of Polarimetry

How do we measure light?

Photometry?

As intensity! (Energy that hits our detector)

Spectroscopy?

Same here! But divided on wavelenghts!

Polarimetry?

Yup, you are right, intensity! But intensity of light that wiggles in specific direction!

And how do we measure this wiggliness thingy?

Are we actually sure that light wiggles?

Maxwell is saying yes!

From Maxwells equations we get

$$\frac{1}{\mu_0 \epsilon_0} \triangle \vec{E} = \frac{\partial^2 \vec{E}}{\partial t^2}$$

And solution is

$$E_x = a_x e^{i(k_x x - \omega t + \delta_x)}$$
$$E_y = a_y e^{i(k_y y - \omega t + \delta_y)}$$
$$E_z = 0$$

Aaaaaaand...

Voila, ellipse...

$$\frac{E_x}{a_x} + \frac{E_y}{a_y} - 2\frac{E_x E_y}{a_x a_y} \cos\delta = \sin^2\delta \tag{2}$$

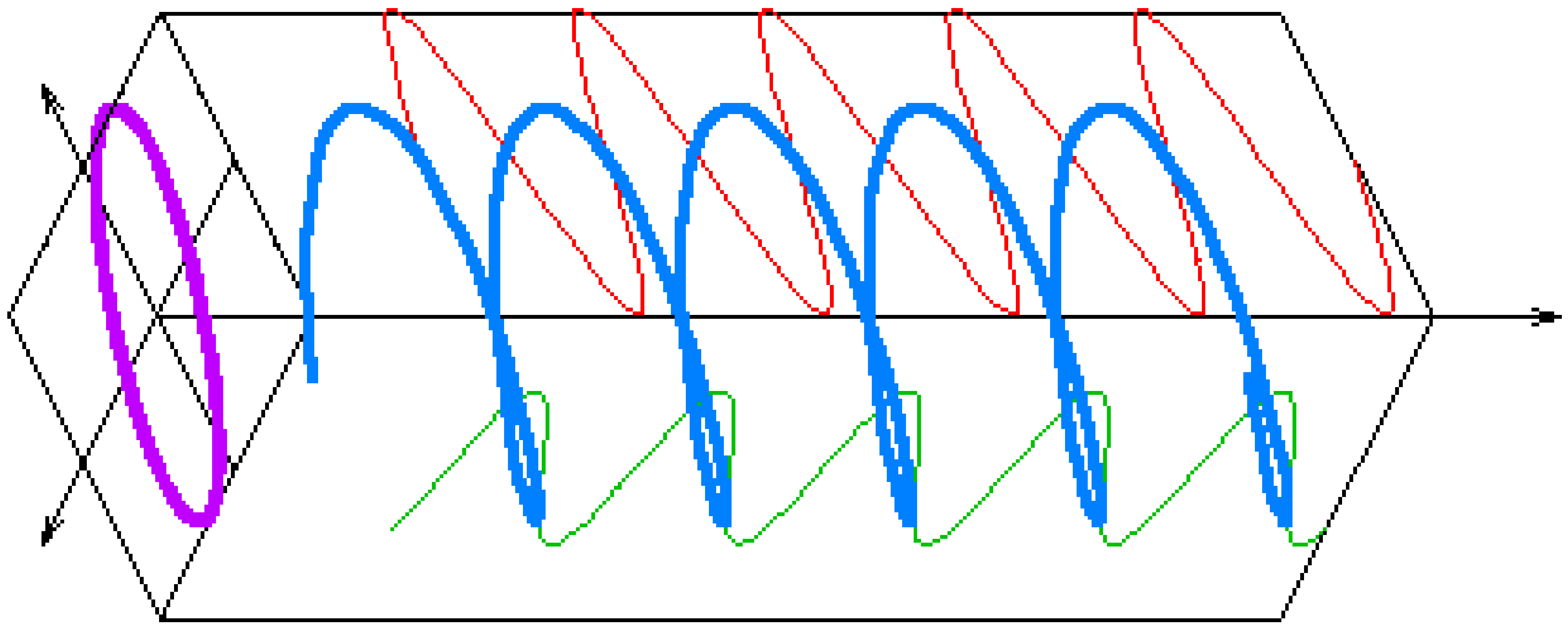


Figure 4: Superposition

Yeah, cool... But you said intensity!

Right...

So we need formalism... Good guy Gabriel Stokes.

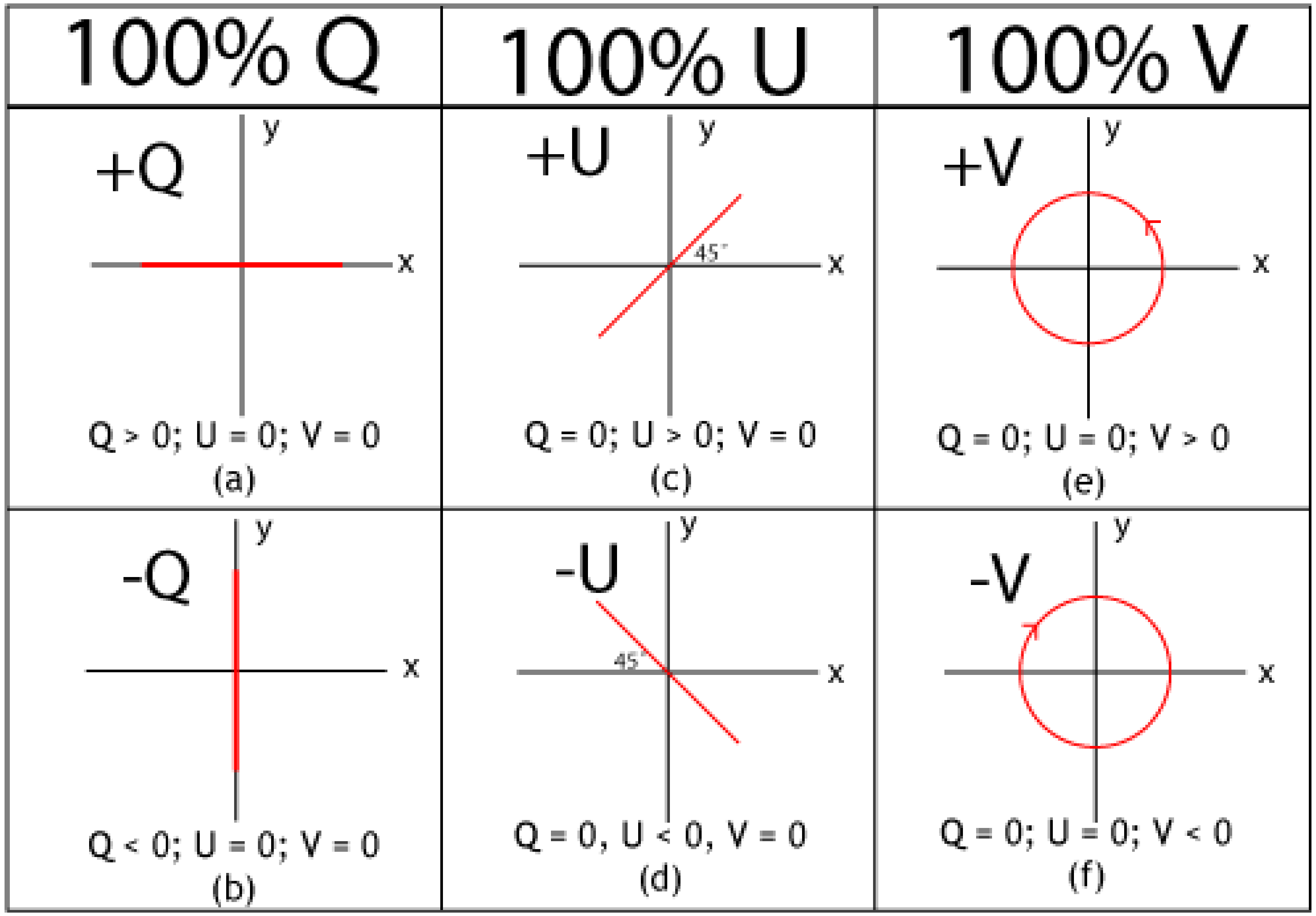


Figure 5: Stokes parameters

Yeah, cool... But you said intensity!

So

By tunning this analyzers we have

$$
\begin{aligned}
I &= I(0,0) + I(\pi/2,0) \\
Q &= I(0,0) - I(\pi/2,0) \\
U &= I(\pi/4,0) - I(3\pi/4,0) \\
V &= I(\pi/4,\pi/2) + I(3\pi/4,\pi/2)
\end{aligned}
$$

Why do we measure all this?

Long answer short...

If light is man's most useful tool, polarized light is the quintessence of utility.

Long answer short... Second take

Because it give us better picture about conditions in which light is created.

Example

Magnetic field VECTOR in medium in which light is created. Photosphere of Sun in my case.

How do we know there is magnetic field on Sun?

Zeeman effect

Splitting of spectral lines in presence of magnetic field.

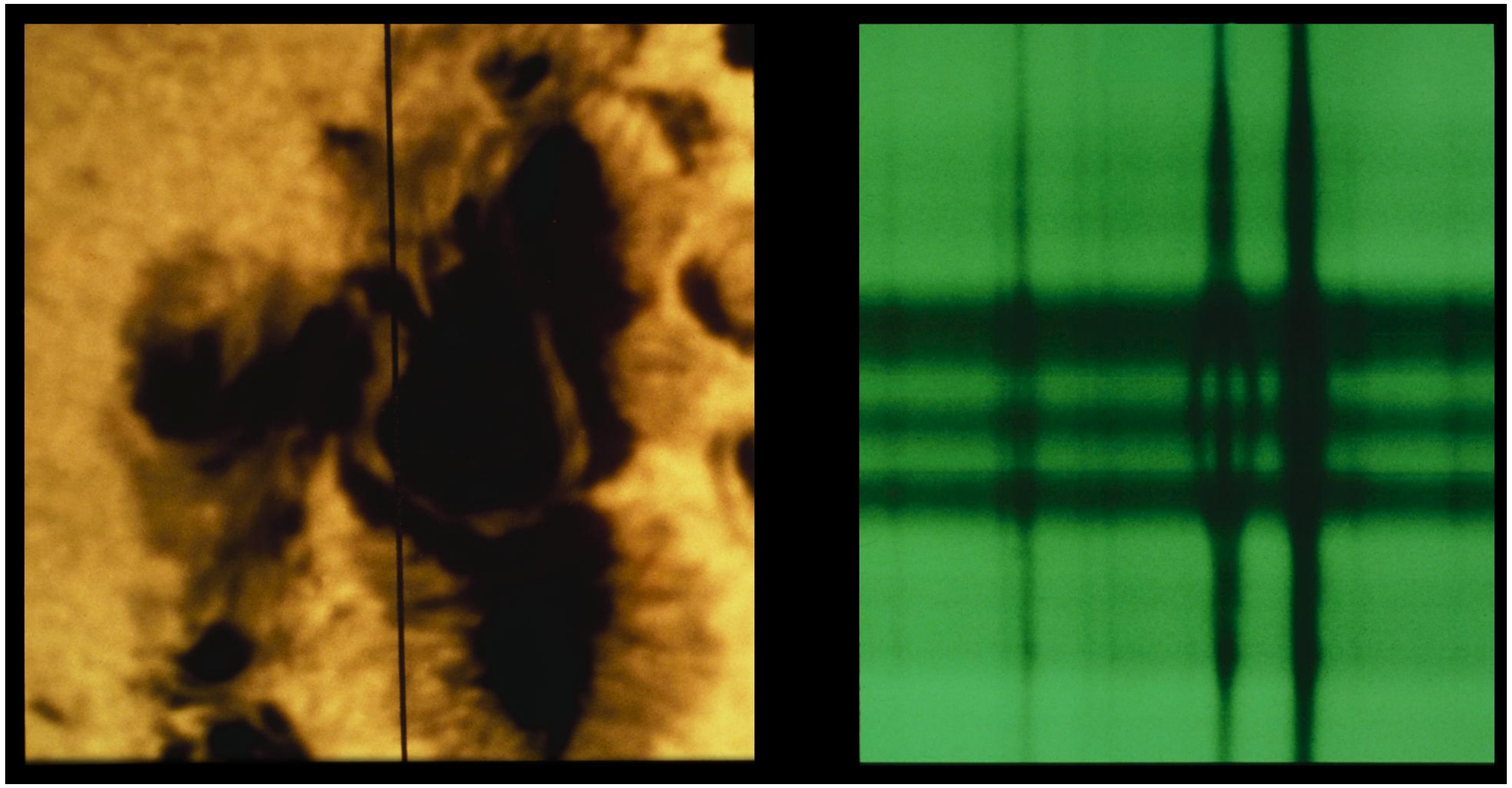


Figure 6: Zeeman effect

Lets take a closer look on I

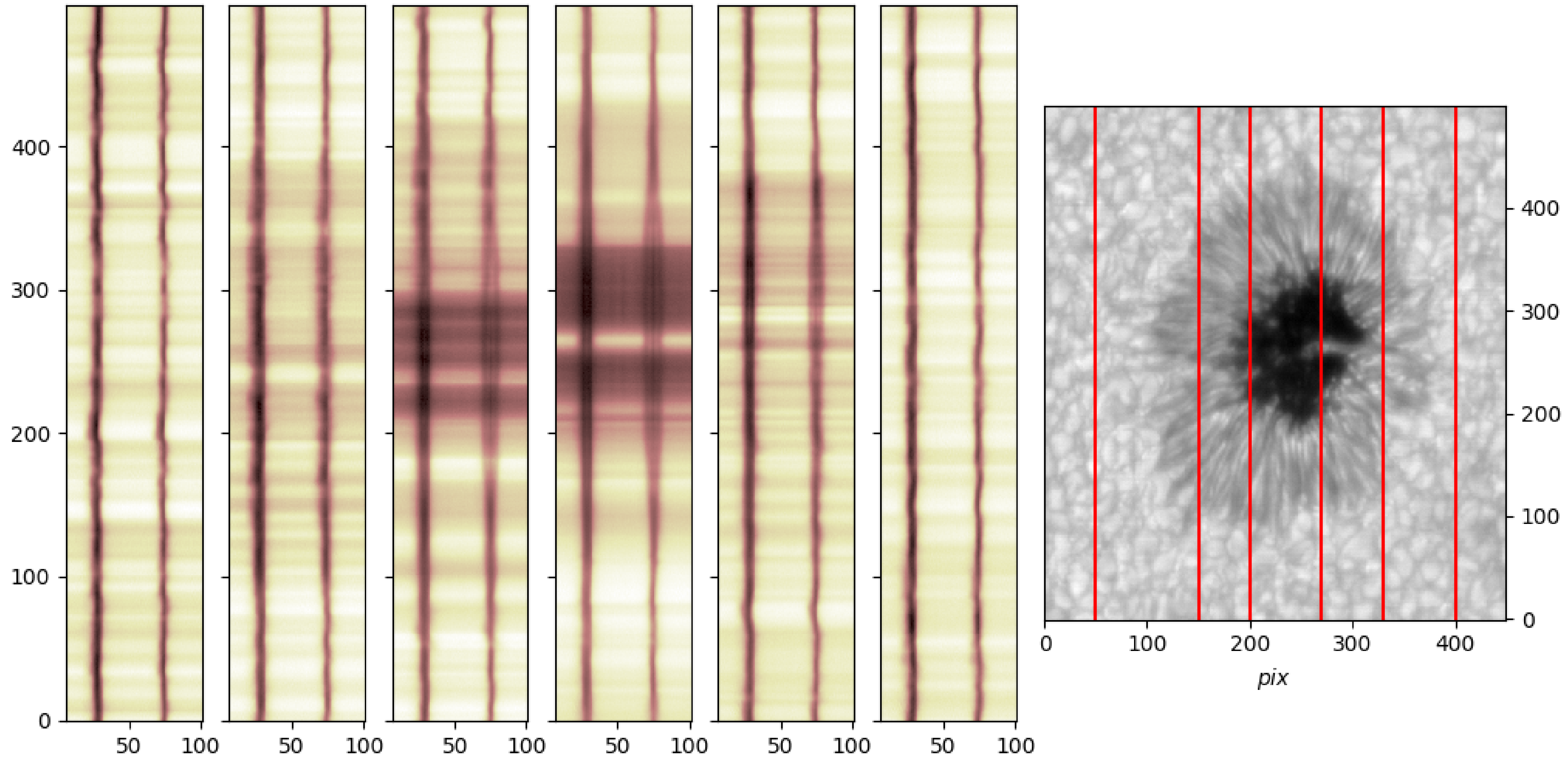


Figure 7: Zeeman effect

Lets take a closer look on V

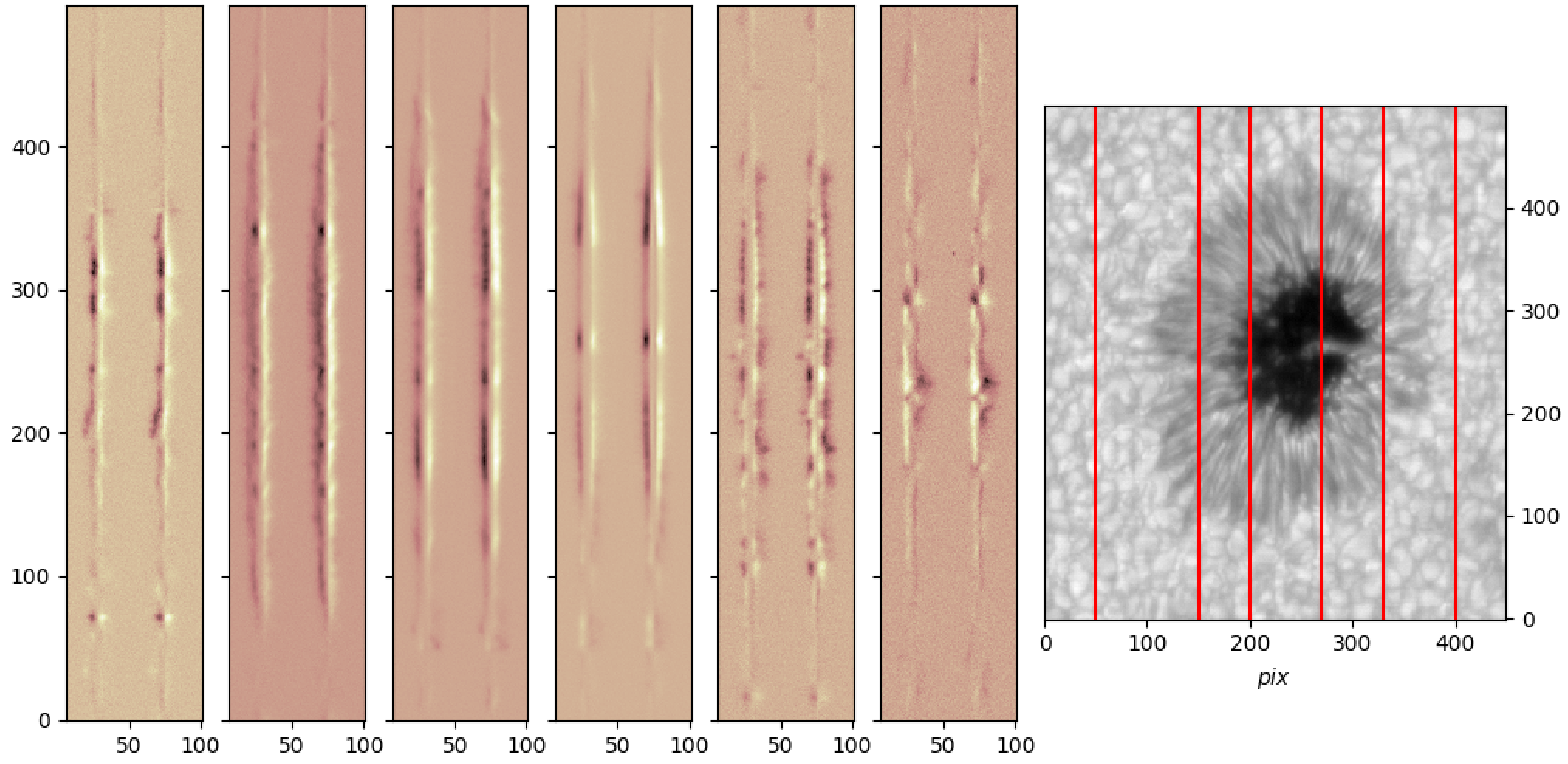


Figure 8: Zeeman effect

So we have this cool loops and spots

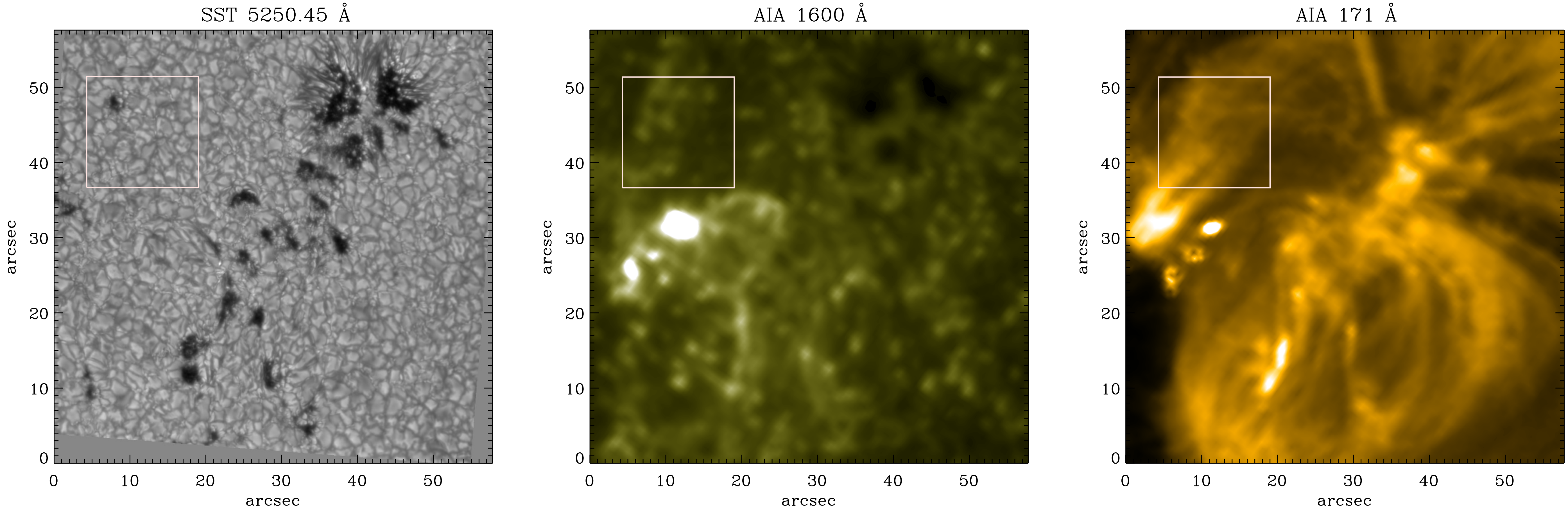


Figure 9: Observed region

What exactly did you wanted to calculate?

Poyntign flux:

.. is energy transfer per unit area per unit time:

$\mathbf{S} \propto \mathbf{E} \times \mathbf{B}$

But in ideal non-resistive MHD

For Ohm's law we have:

$\mathbf{E} + \mathbf{v} \times \mathbf{B} = 0$

So we can write S as:

$\mathbf{S} \propto \mathbf{B} \times (\mathbf{v} \times \mathbf{B})$

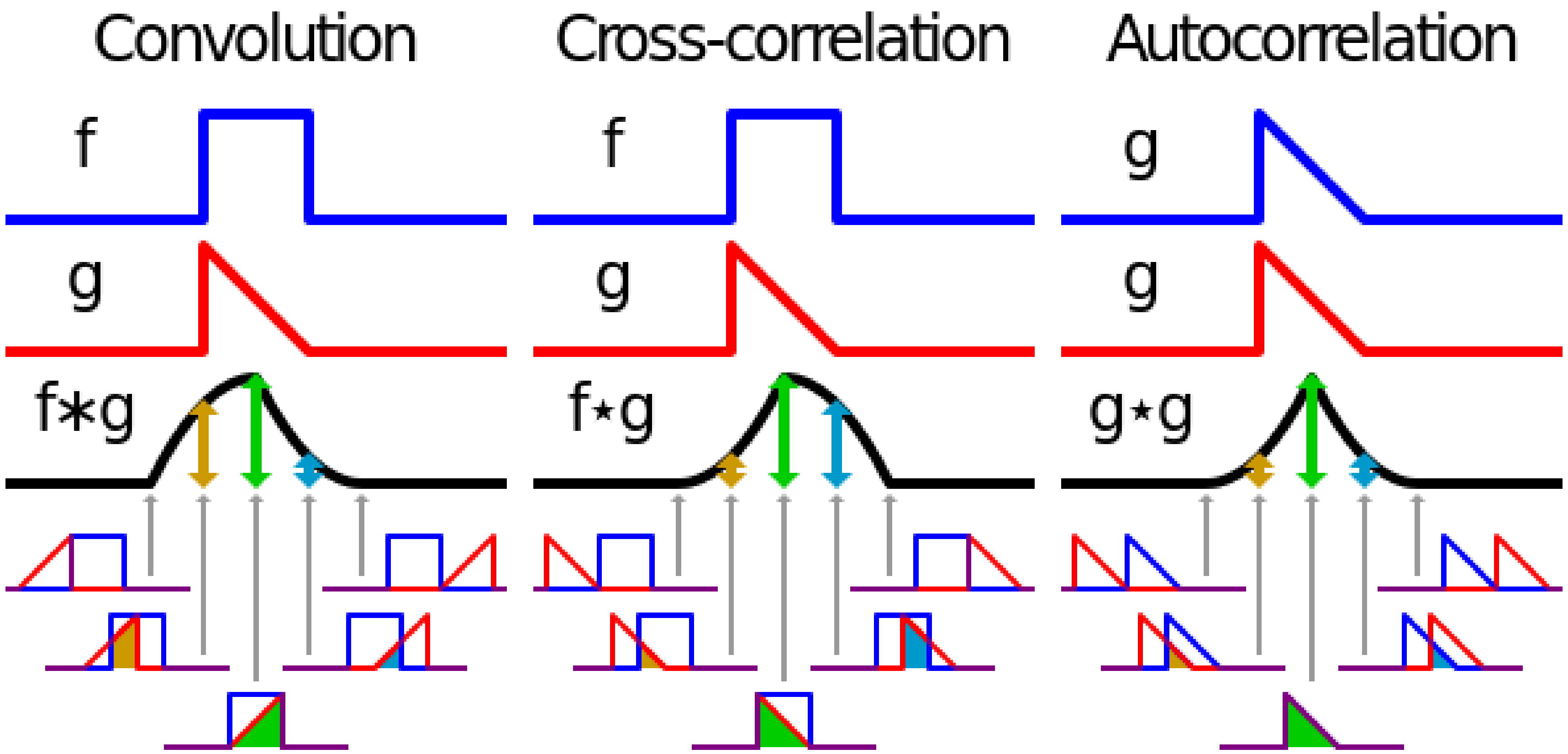
But we are only interested in vertical component:

$S_z \propto [v_z B_h^2 - (\mathbf{v}_h \cdot \mathbf{B}_h) B_z] \simeq -(\mathbf{v}_h \cdot \mathbf{B}_h) B_z$

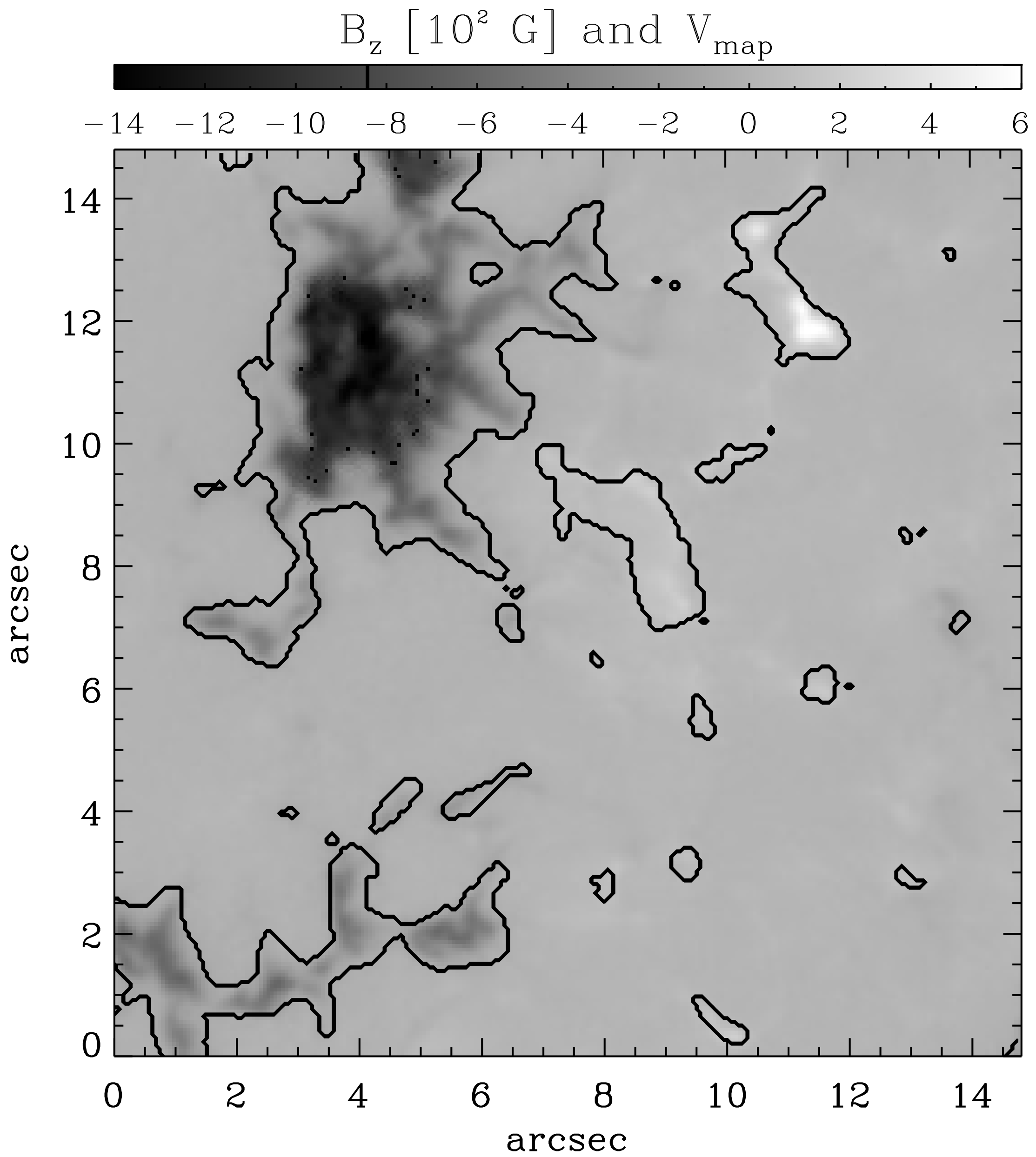
Cross-correlation and velocity of things

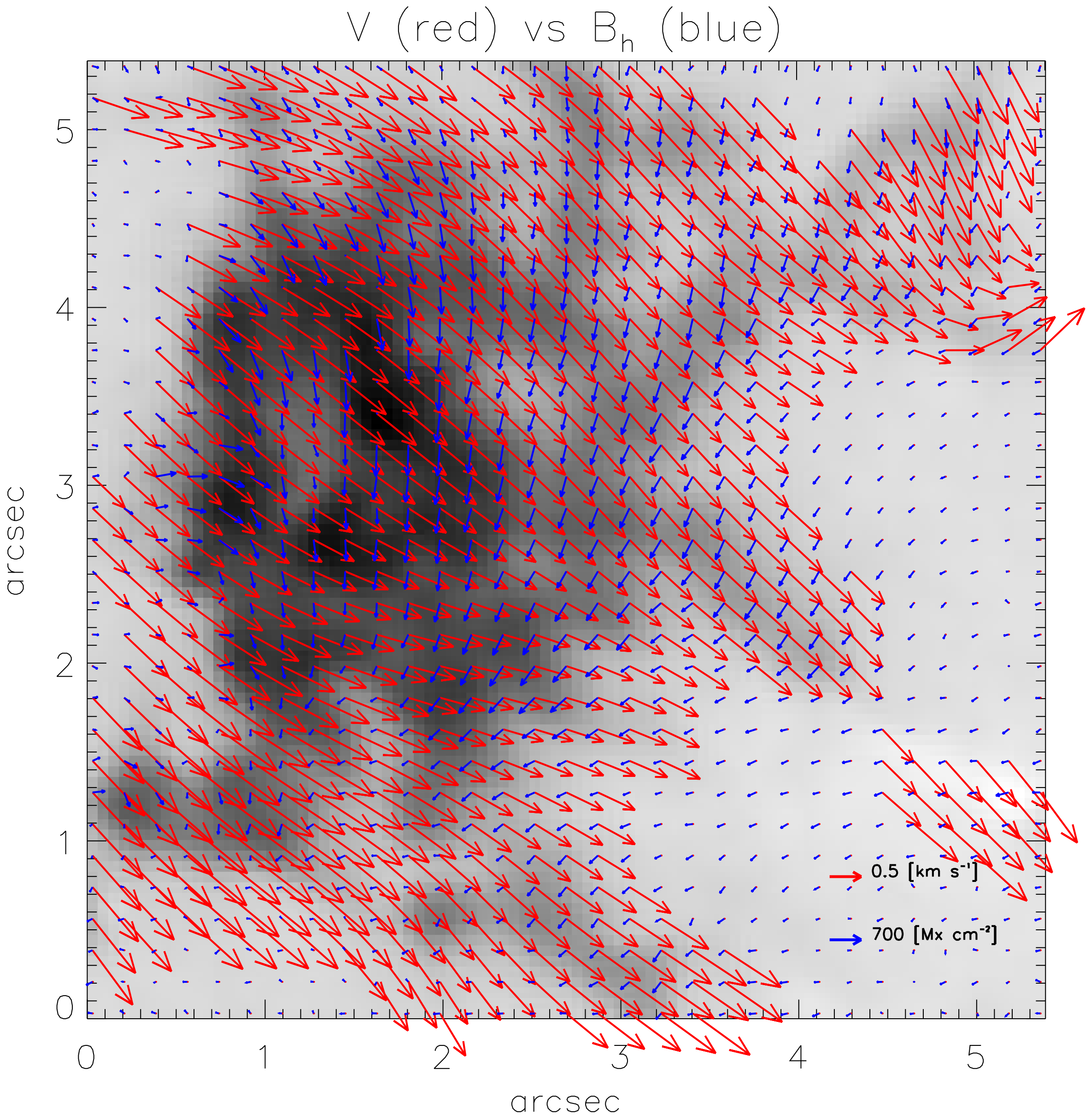
Function of correlation

$C(\tau) = \int_{-\infty}^{\infty} f(x)g(x+\tau)dx$

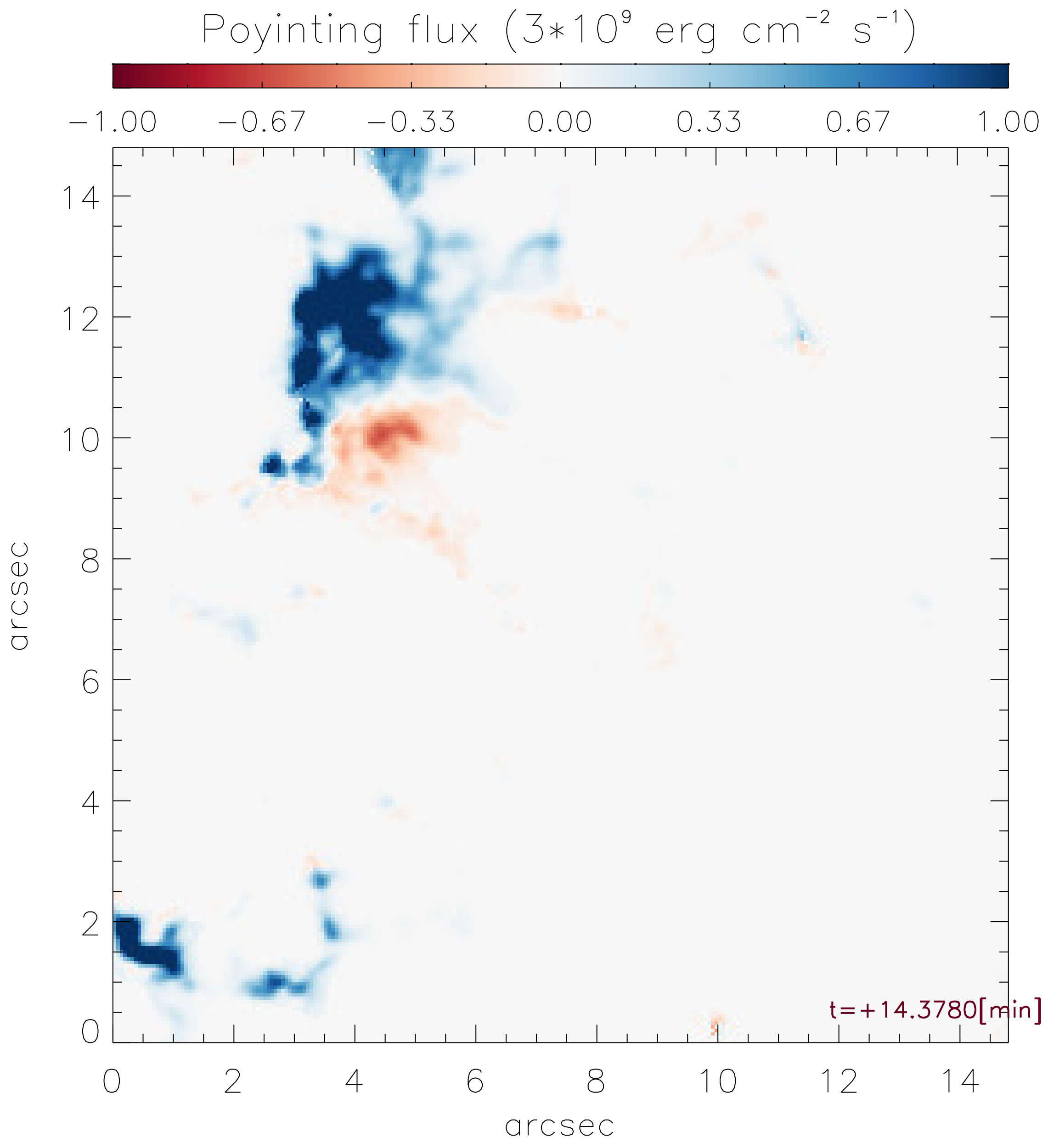


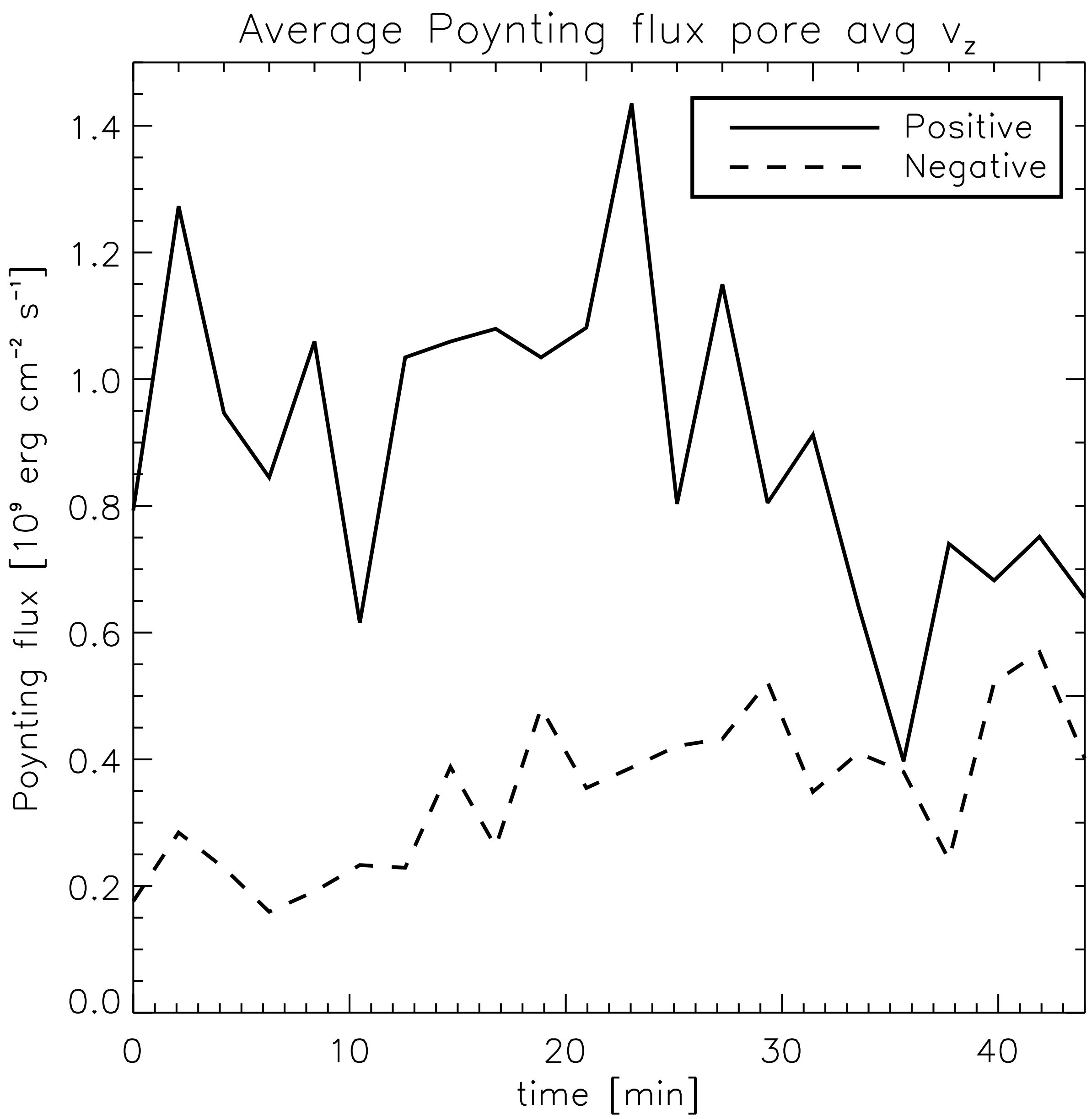
B and velocity





And what about Poynting flux at the end?





What this actually means?

Heating?

We have evidence that there is upwards pointing energy flux and that its time average is positive and energy input is order of needed for coronal heating.

So cool, we have solved coronal heating problem!

Well, no. Remember, this is photosphere, we dont know if this energy even gets to the chromosphere or any upper layer of Suns atmosphere.

But...

I have images of chromosphere for the same time series as this photospheric images... Need to check that out....