Spectropolarimetric Imaging of the photosphere of Betelgeuse

A. López Ariste

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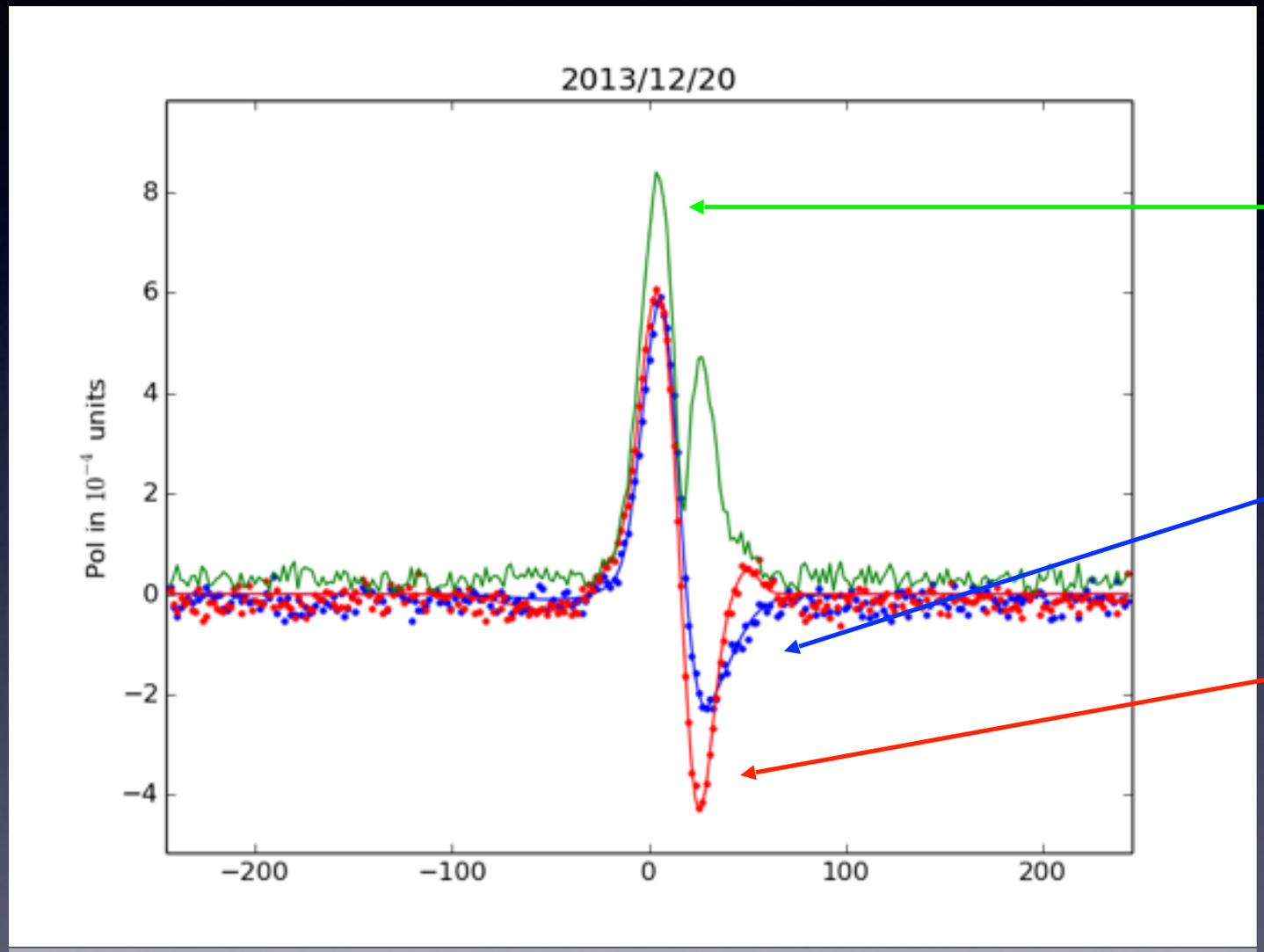
LSD profiles of Linear Polarisation from Betelgeuse



$\sqrt{Q^2 + U^2}$

Q

U

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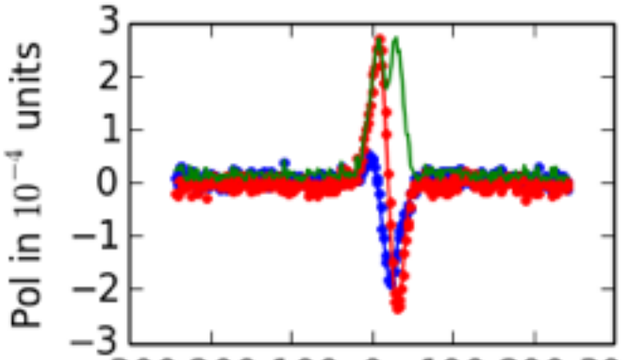
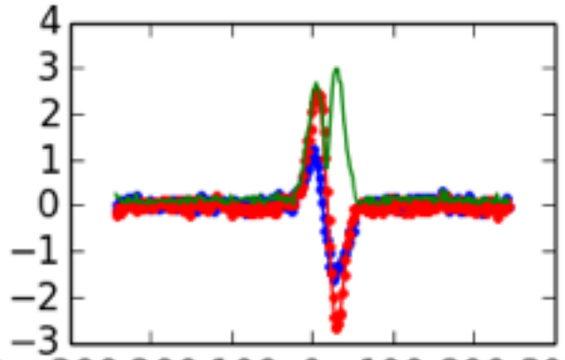
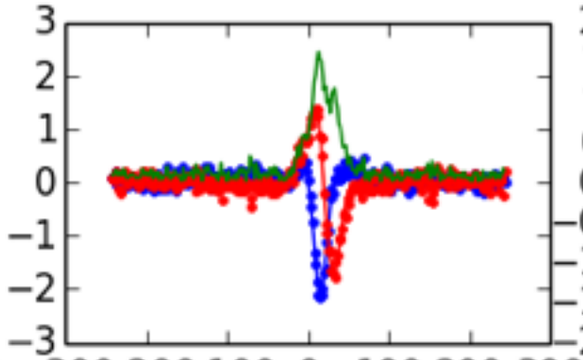
15/09/19



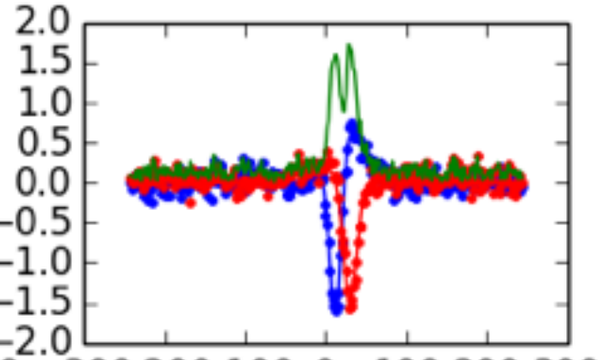
15/10/16

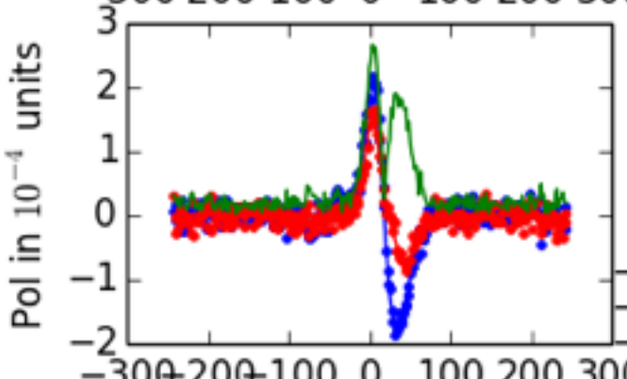


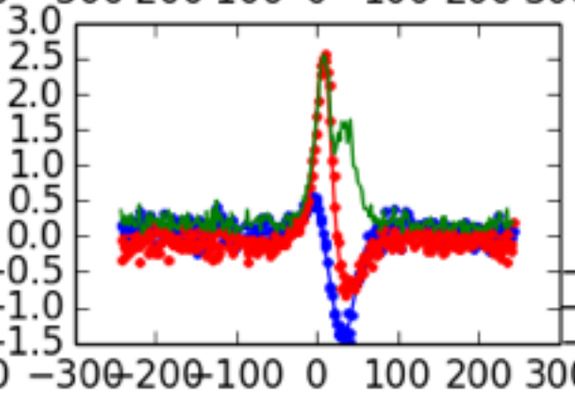
15/12/09

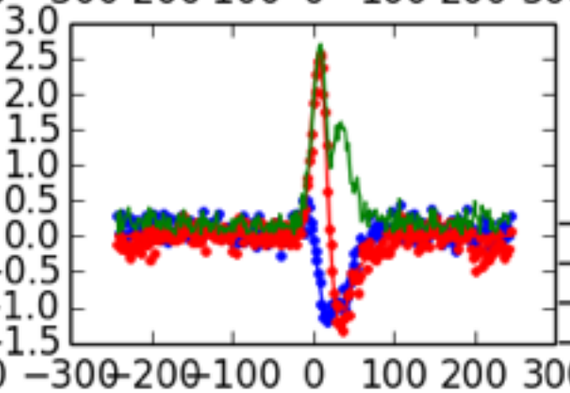


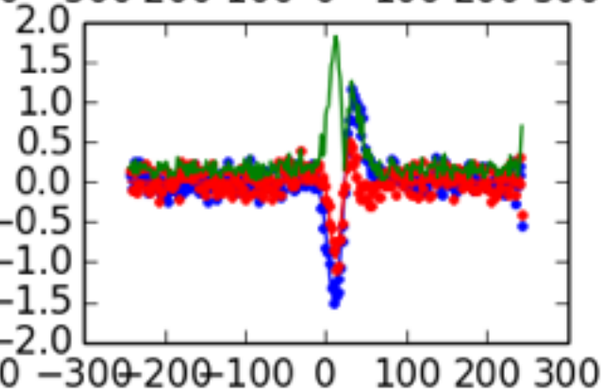
16/01/20

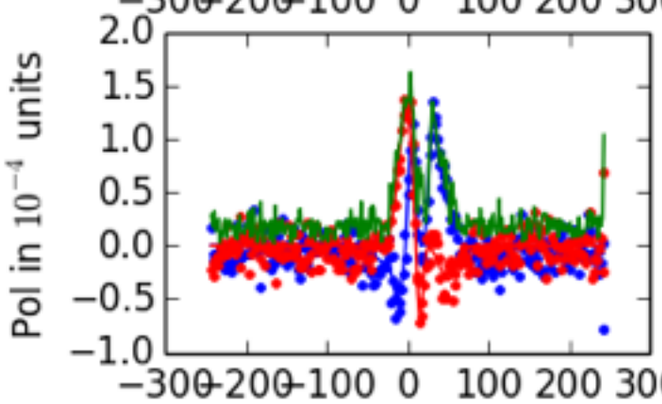












17/04/03

The origin of linear polarization

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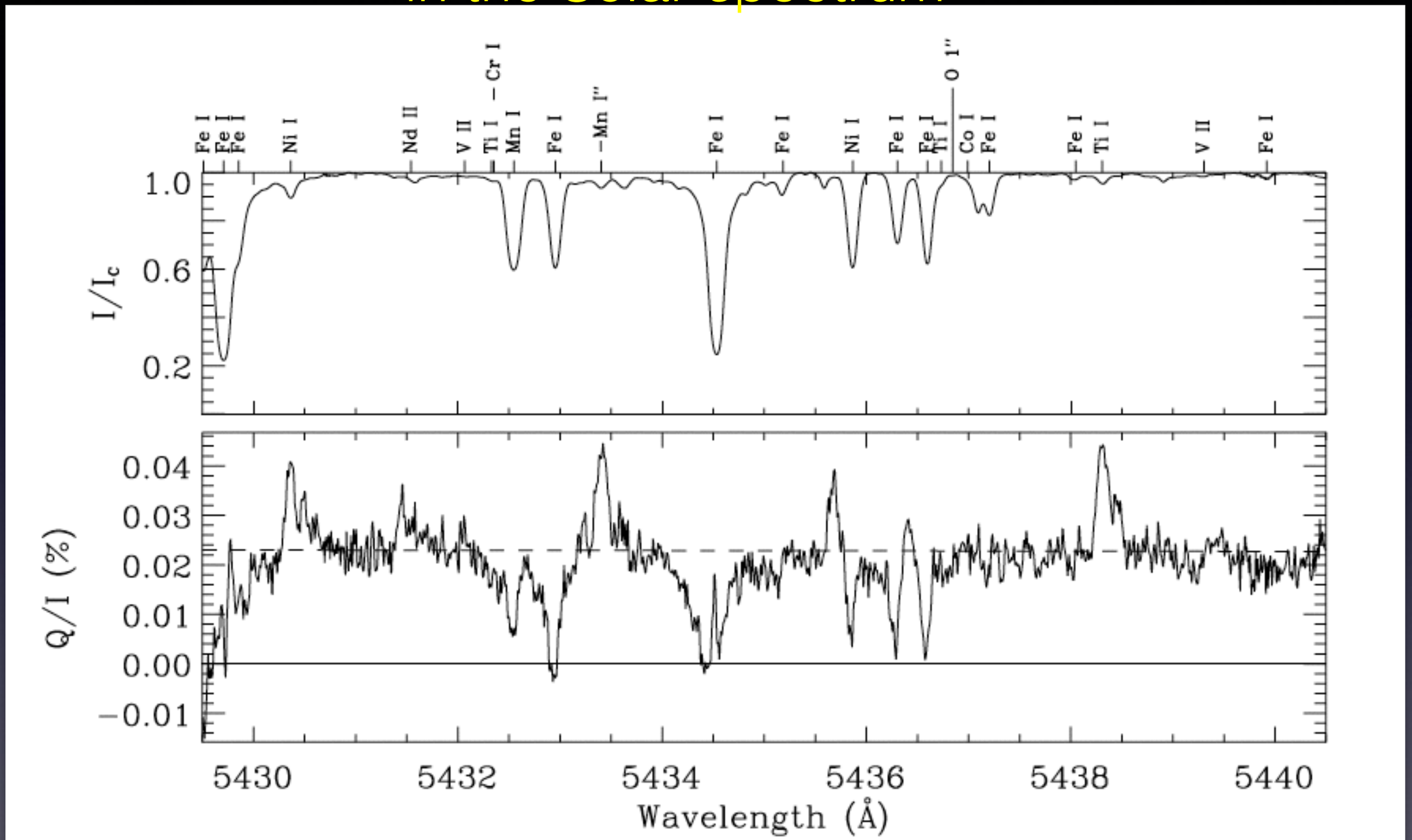
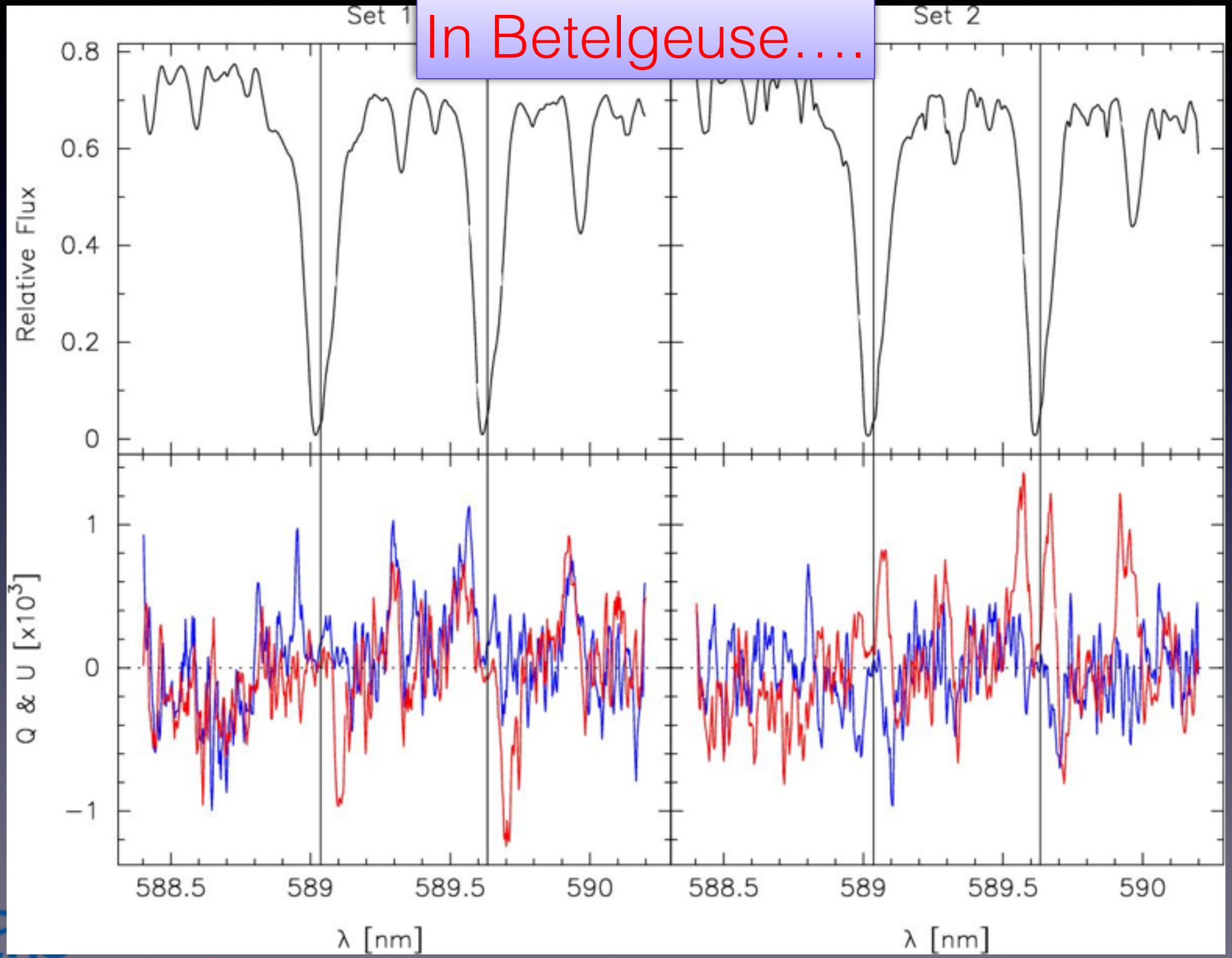
Polarisation and Depolarisation in the Solar spectrum

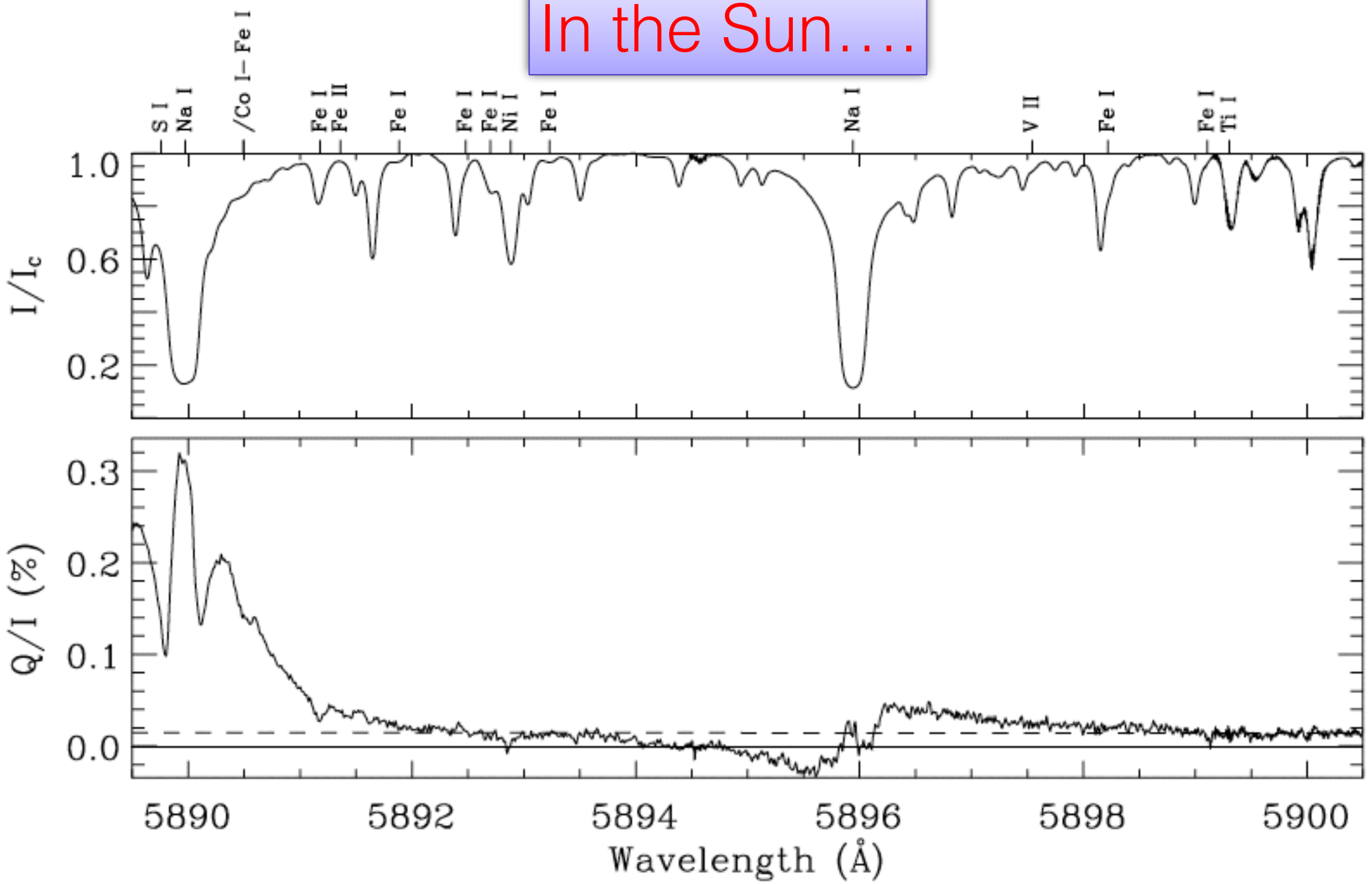


A. Gandorfer, “Atlas of the 2nd Solar Spectrum”

The key: Na D1 and D2



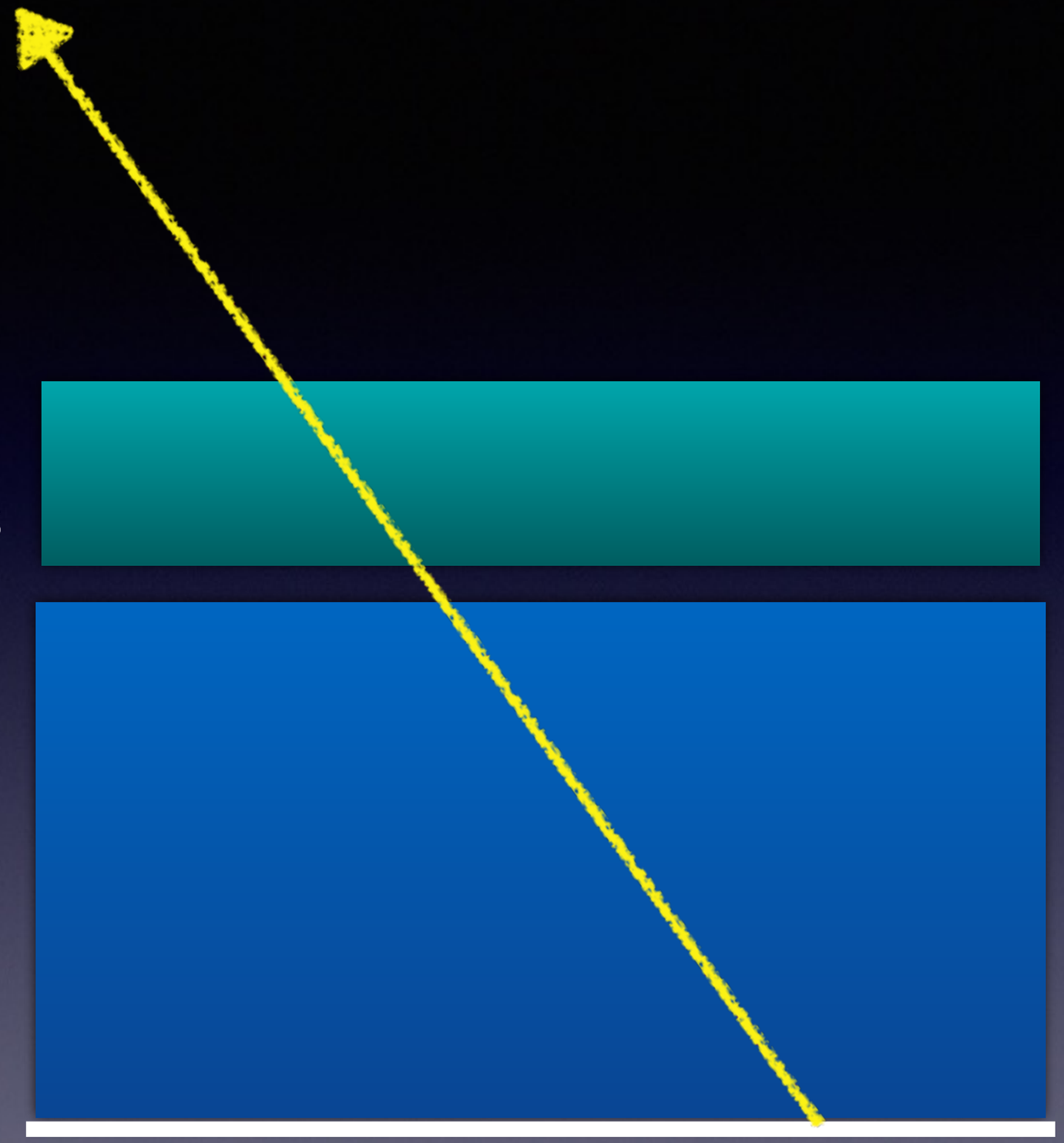
In the Sun….


S I
Na I
/Co I– Fe I
Fe I
Fe II
Fe I
Fe I
Fe I
Ni I
Fe I
Na I
V II
Fe I
Fe I
Ti I
I/I$_c$
1.0
0.6
0.2
Q/I (%)
0.3
0.2
0.1
0.0
5890
5892
5894
5896
5898
5900
Wavelength (Å)

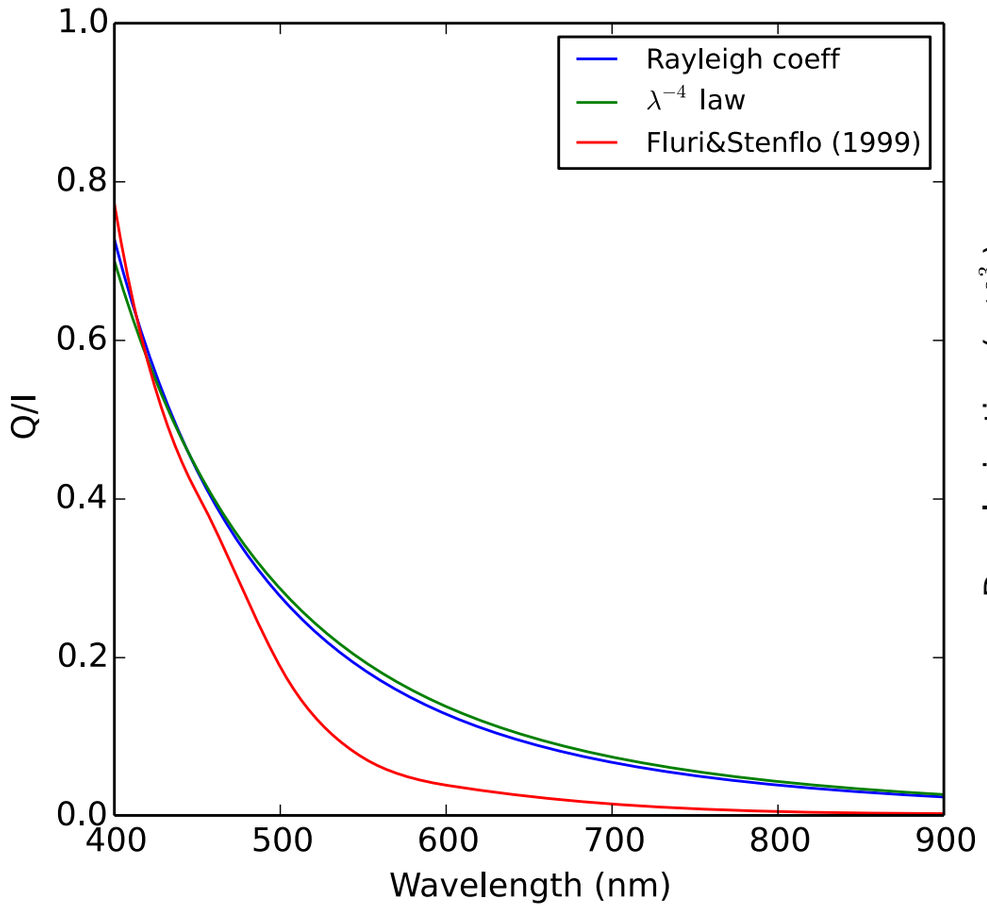
Forming lines absorb polarised photons and re-emit unpolarised ones

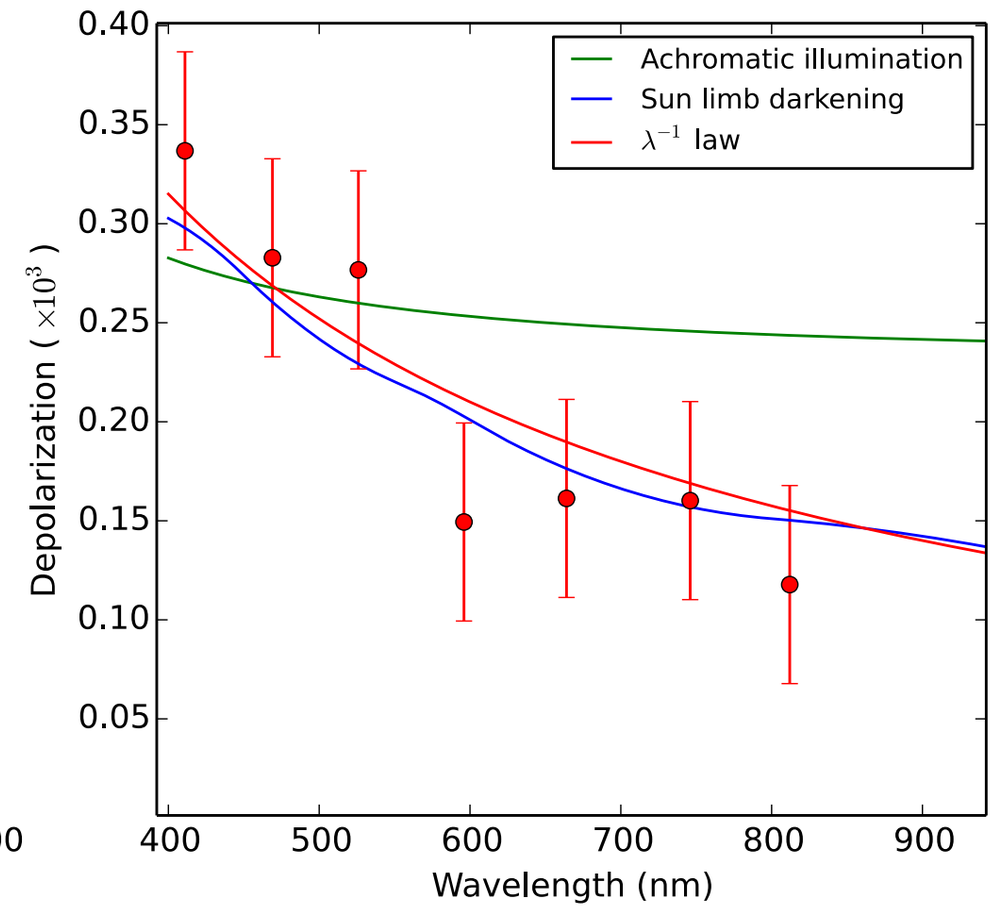
Rayleight scattering polarises continuum

Continuum forms



If it is scattering polarization, it should be larger in the blue, smaller in the red…





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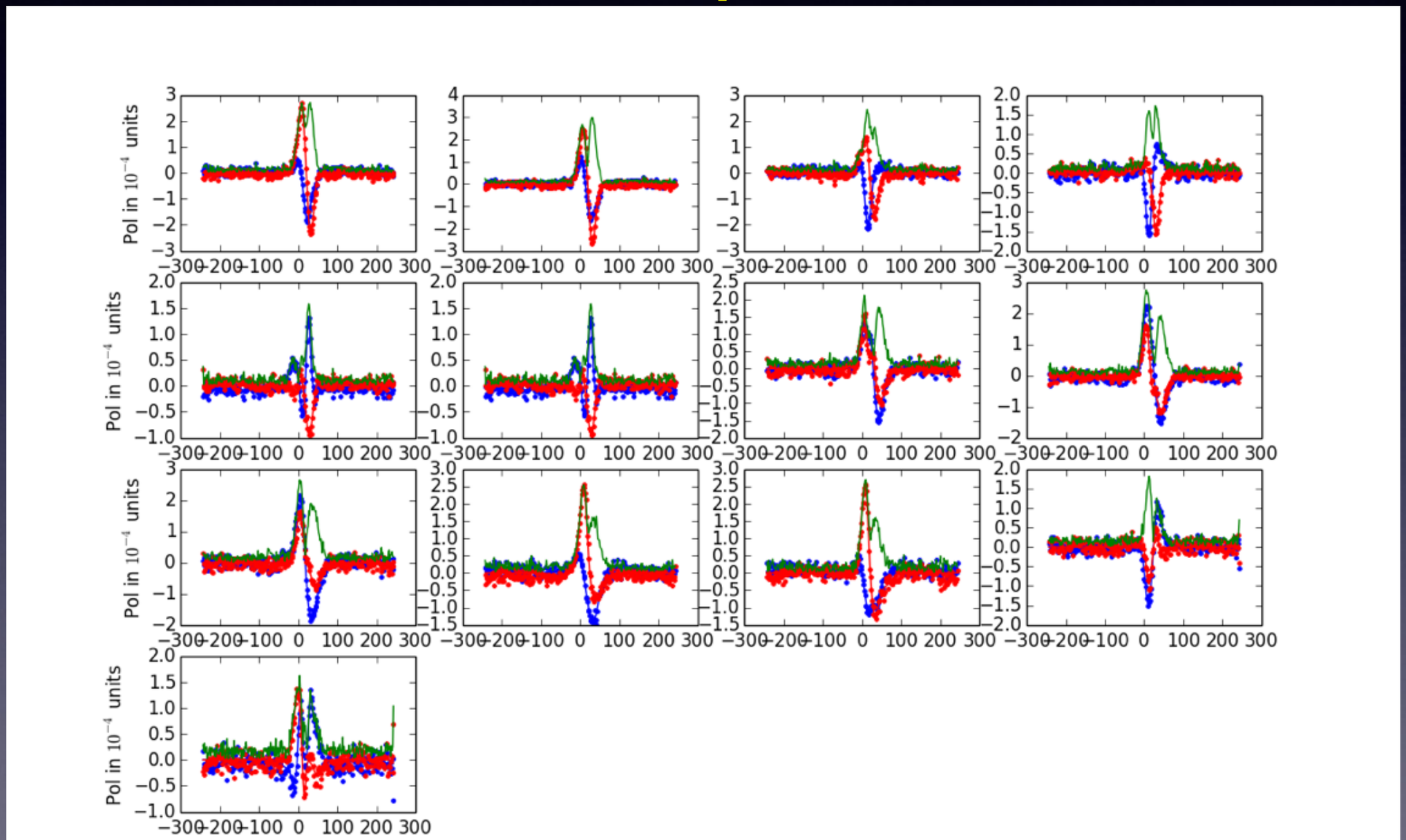
After doing LSD over the whole spectrum….



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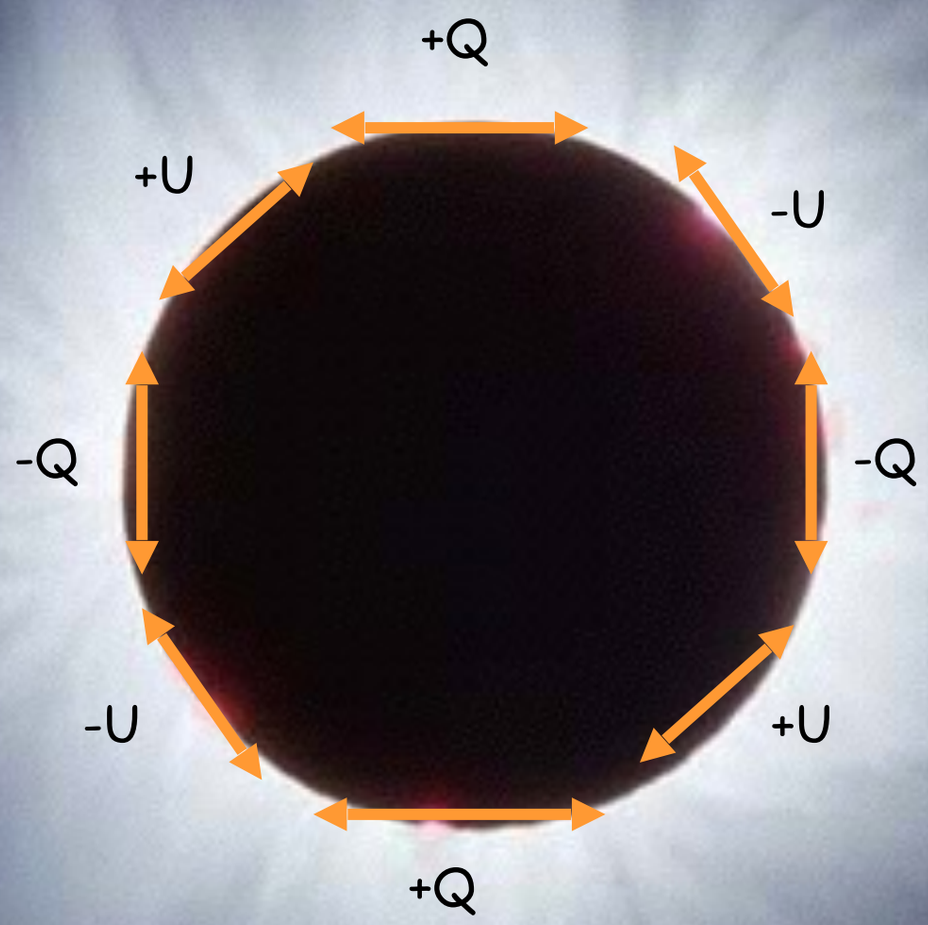
But why there is a net signal after integrating over the disk?



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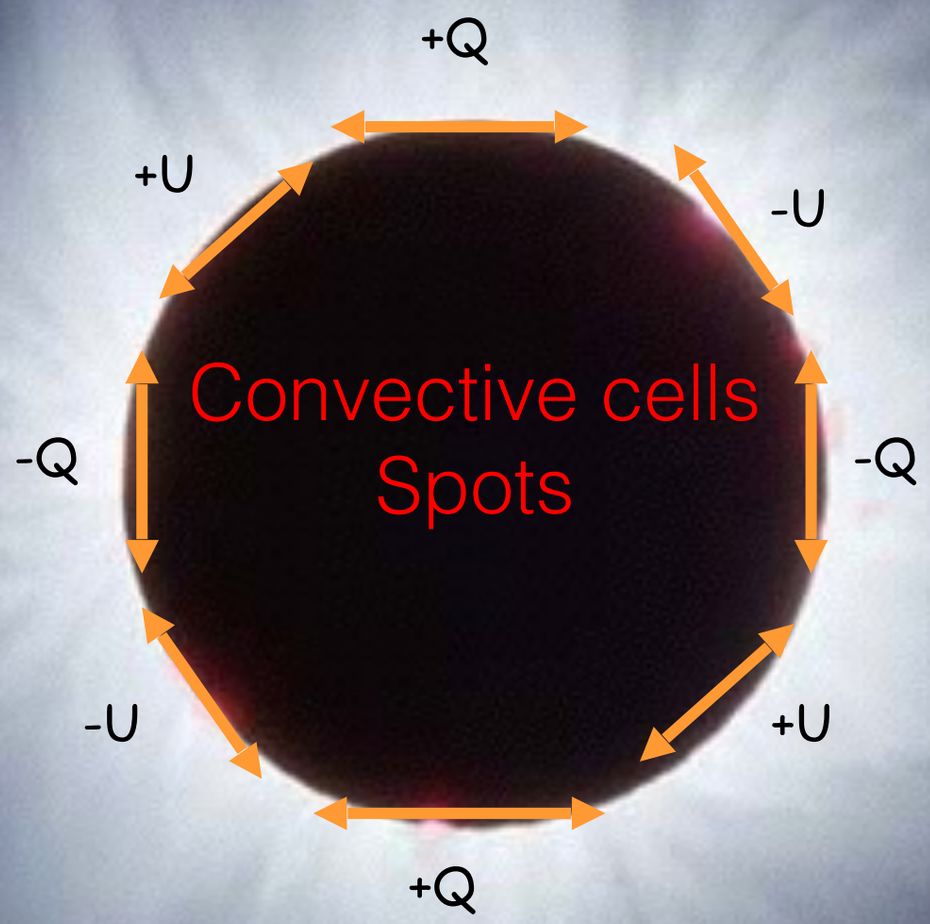

First approximation:

One wavelength, one spot

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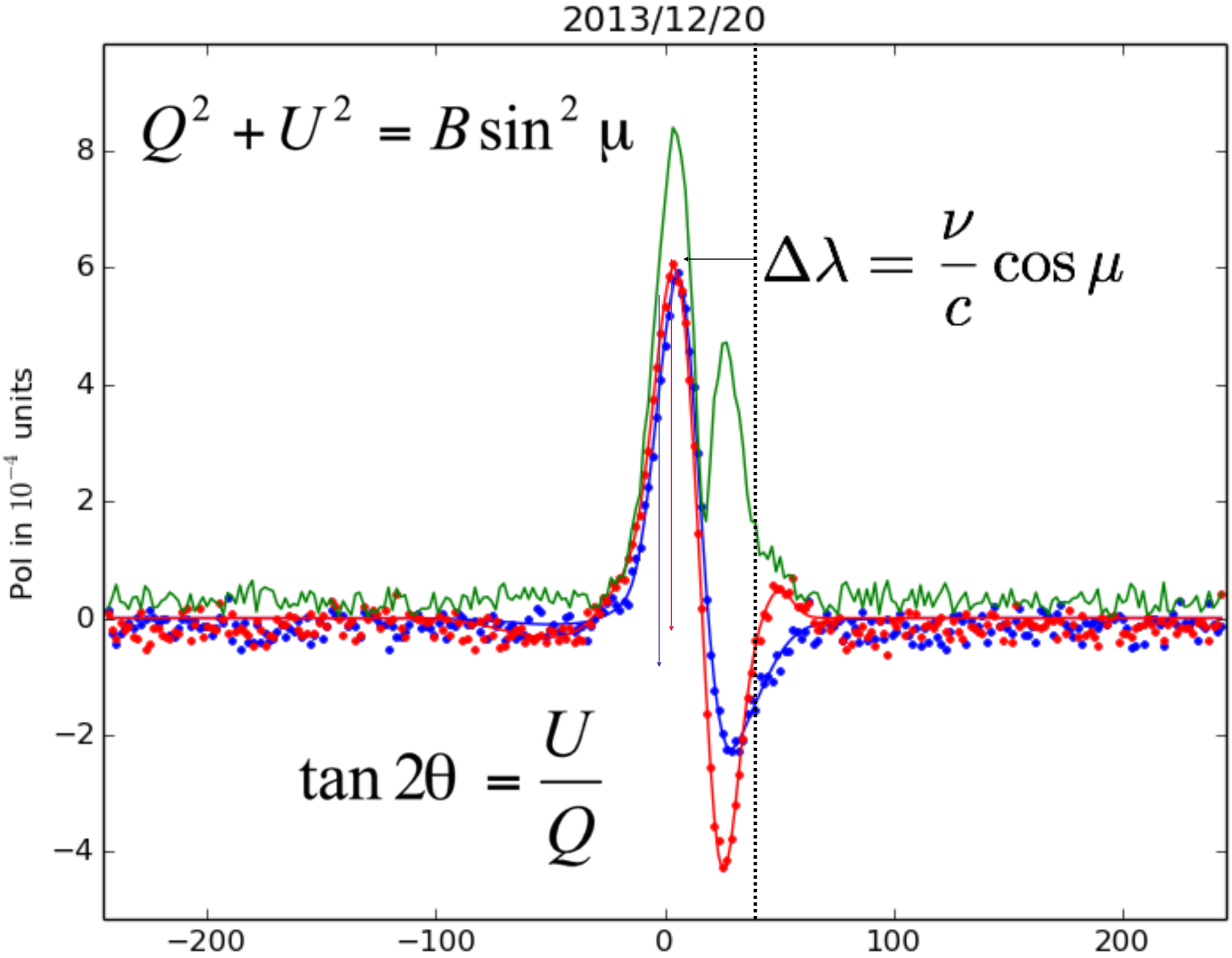
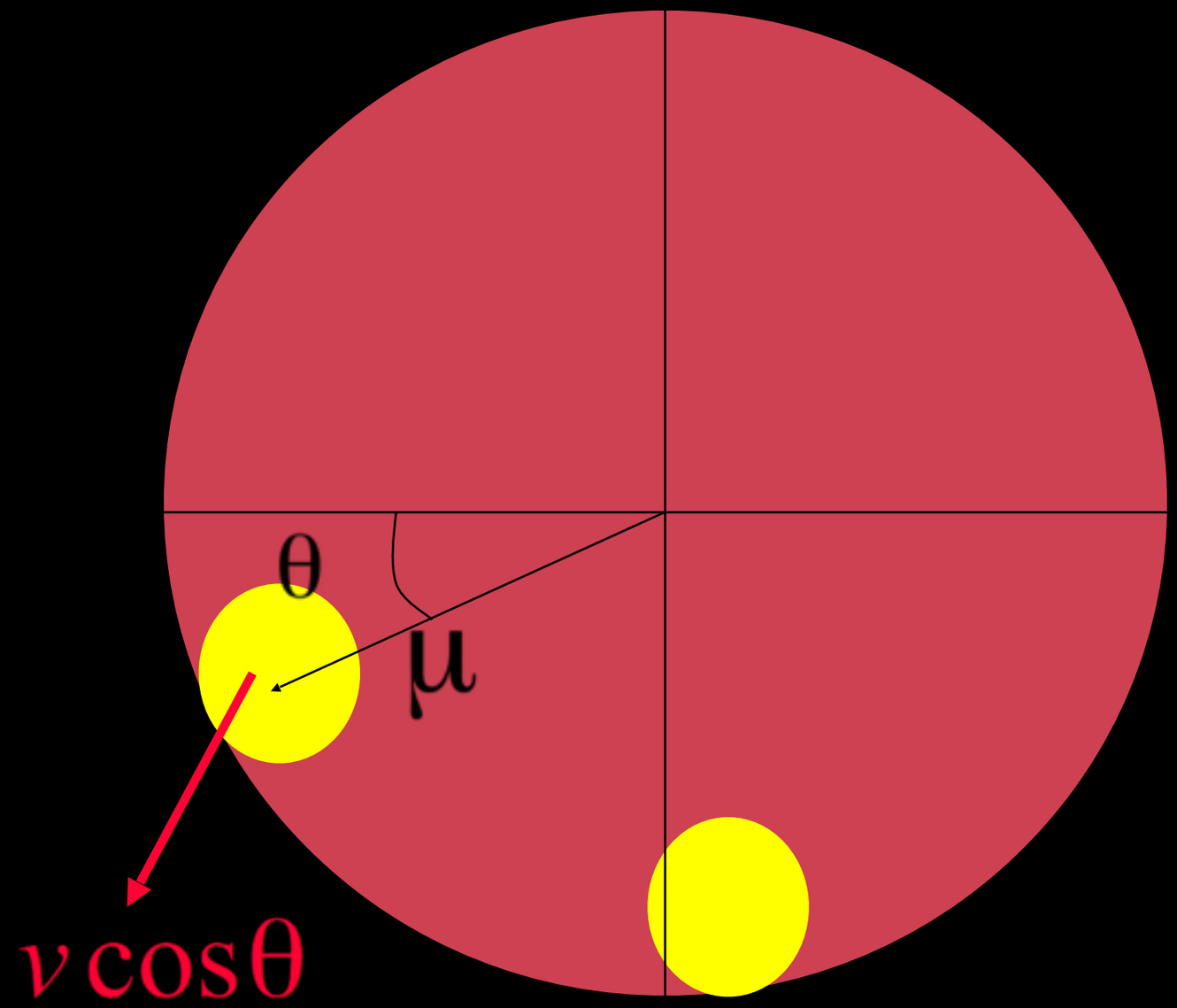
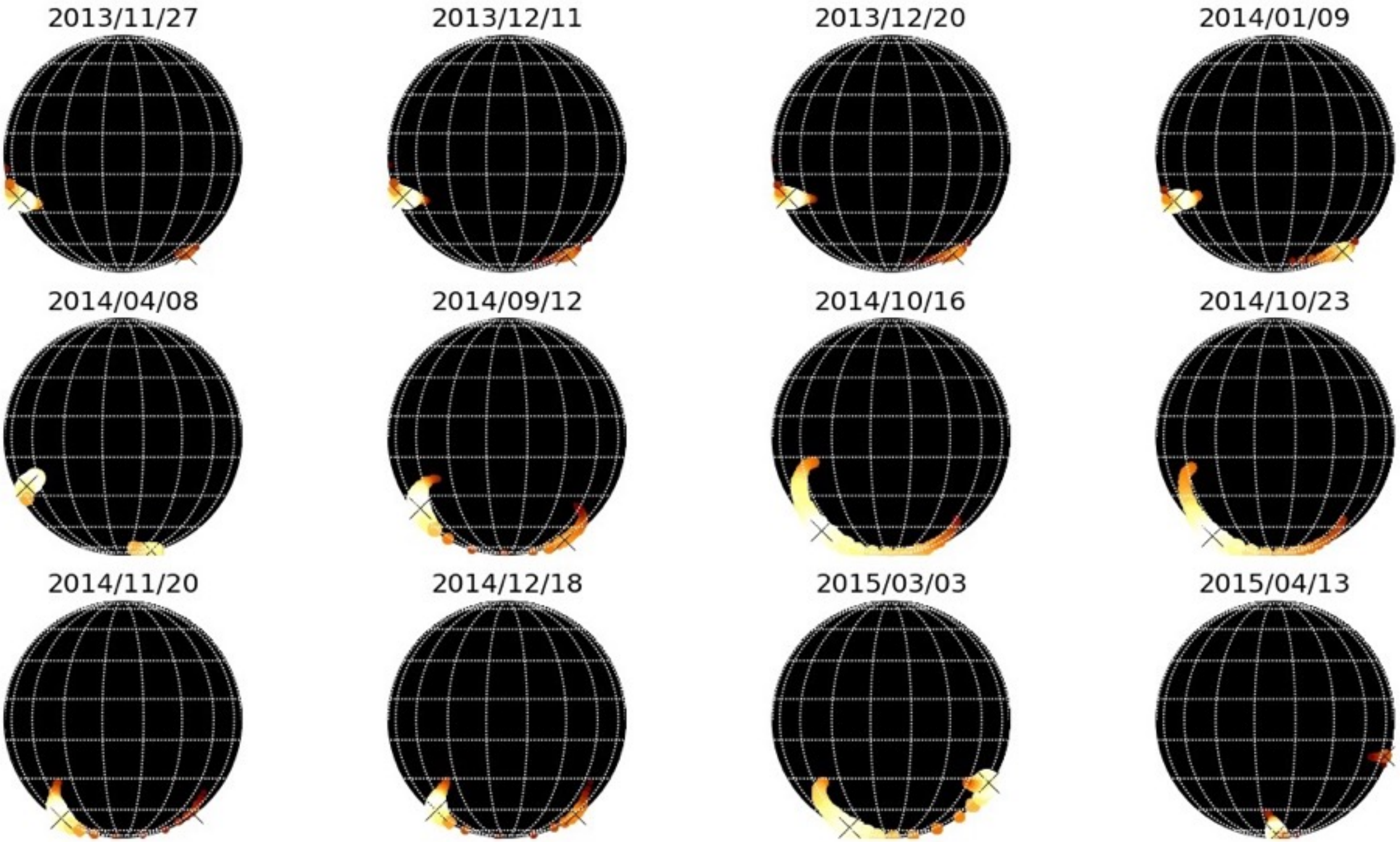

2013/12/20
$Q^2 + U^2 = B \sin^2 \mu$
$\Delta\lambda = \frac{\nu}{c} \cos \mu$
$\tan 2\theta = \frac{U}{Q}$
Pol in 10^{-4} units
8
6
4
2
0
−2
−4
−200
−100
0
100
200

$$\tan 2\theta = \frac{U}{Q}$$

$$Q^2 + U^2 = B \sin^2 \mu$$

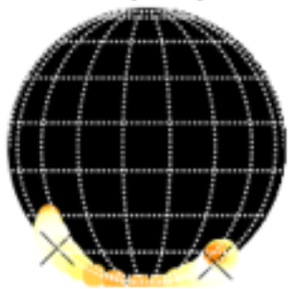


$$\Delta\lambda = \frac{\nu}{c}\cos\theta$$

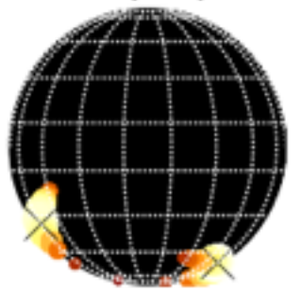


Aurière et al. (2016)

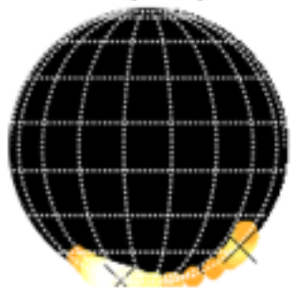
2015/09/19



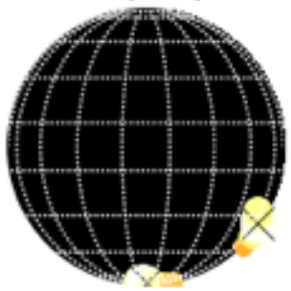
2015/10/16



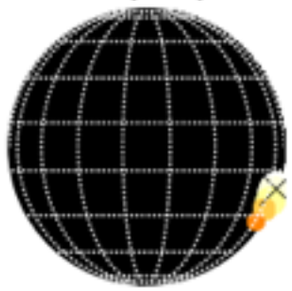
2015/12/09



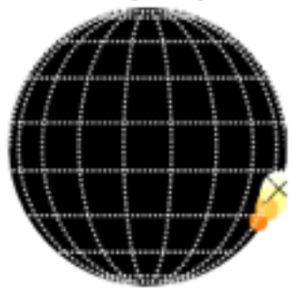
2016/01/20



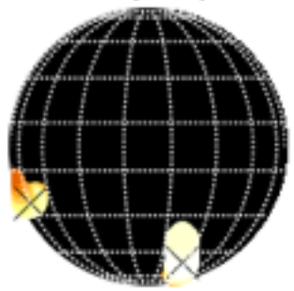
2016/02/16



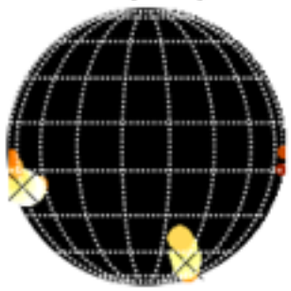
2016/03/12



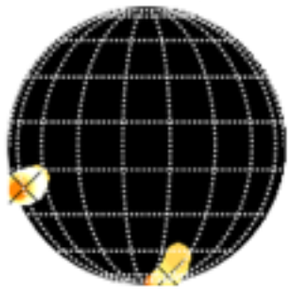
2016/09/11



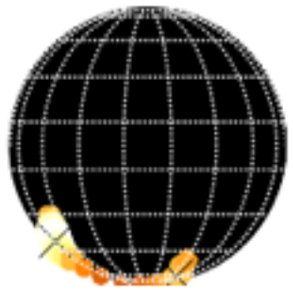
2016/10/08



2016/11/01



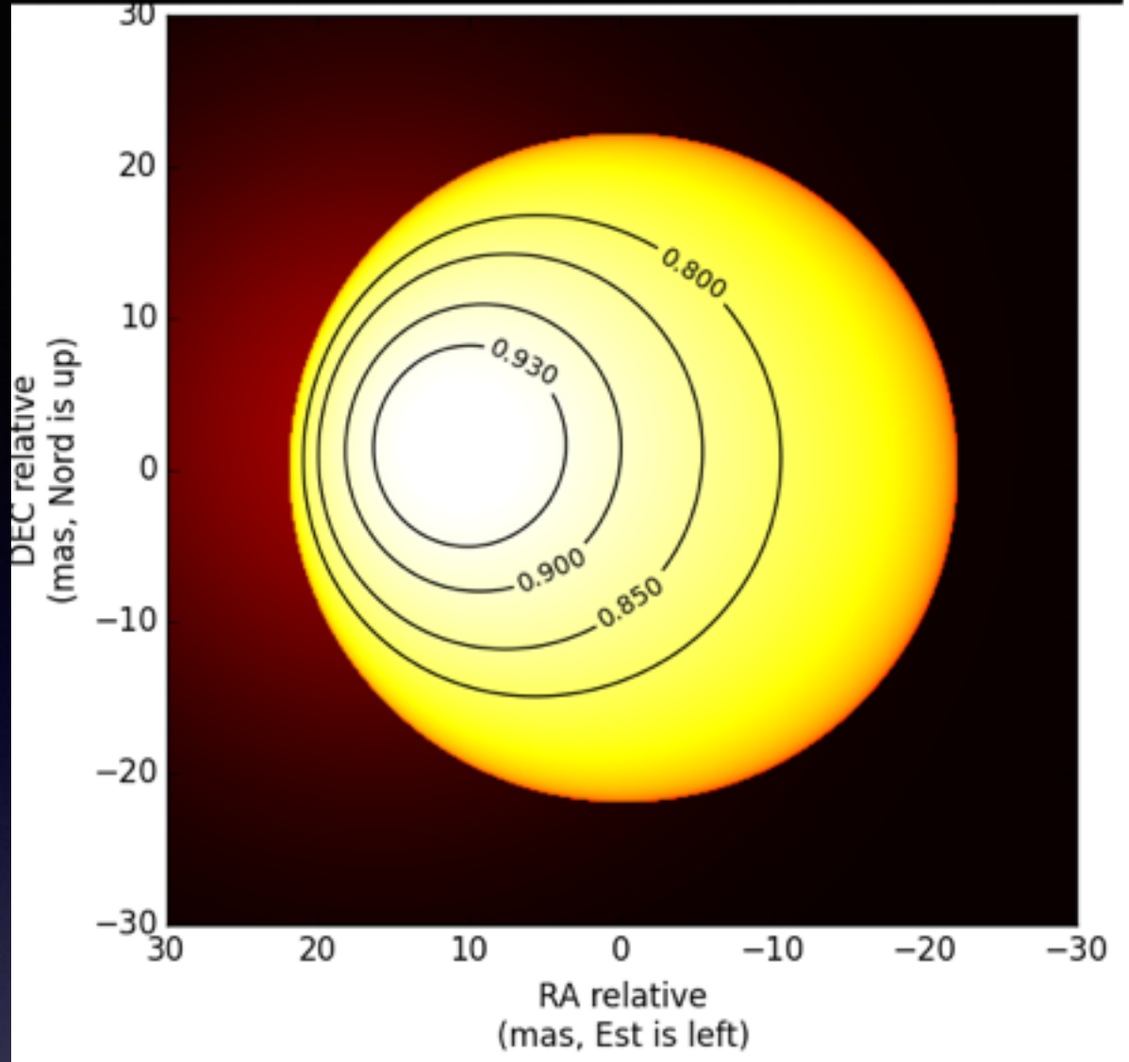
2016/12/03



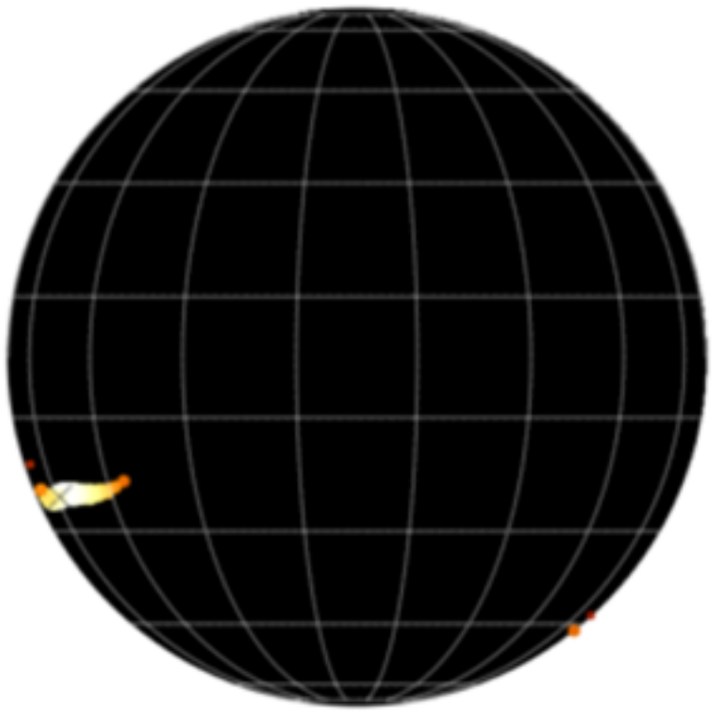
2016/12/18

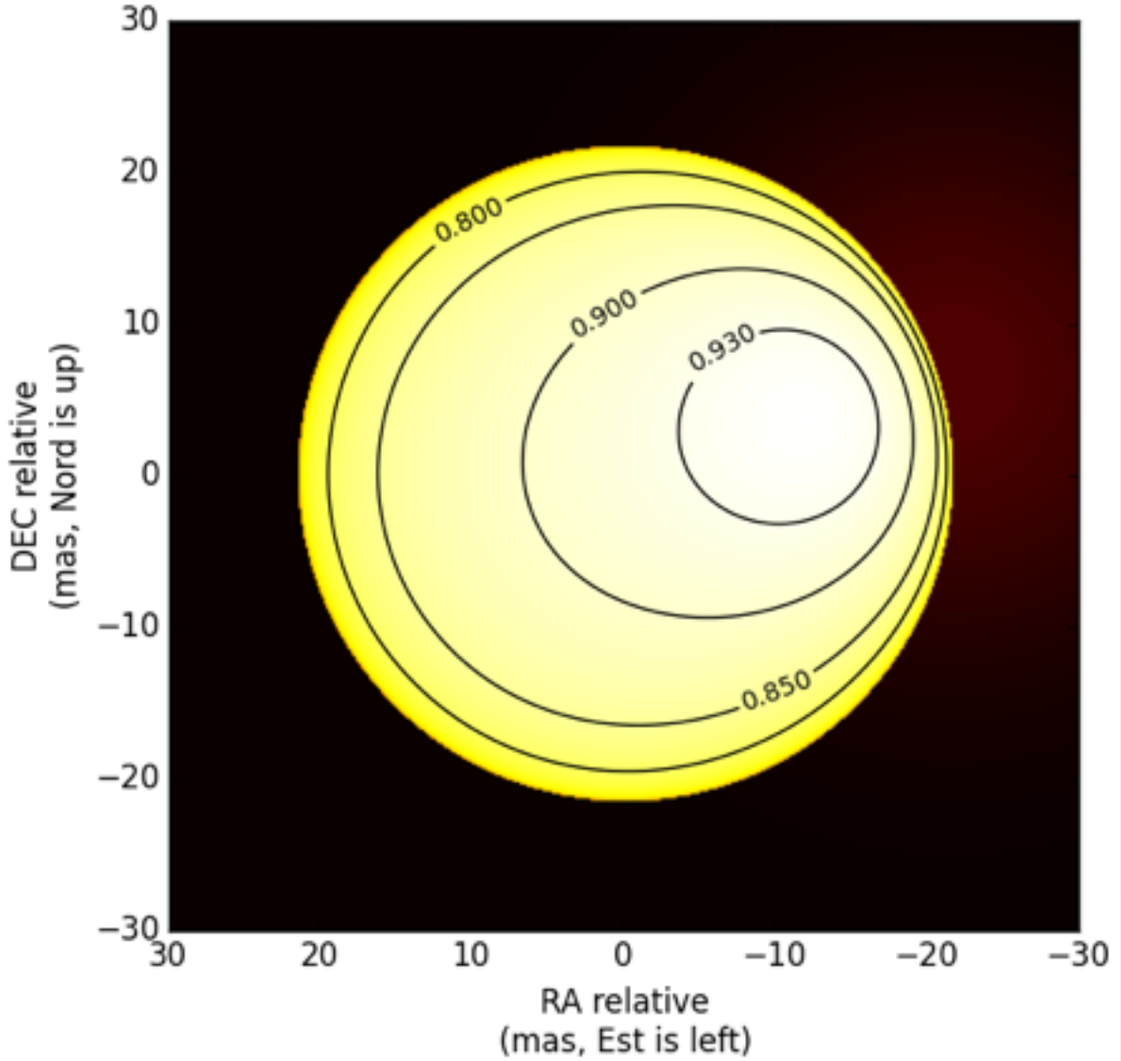
2017/02/17

2017/04/03

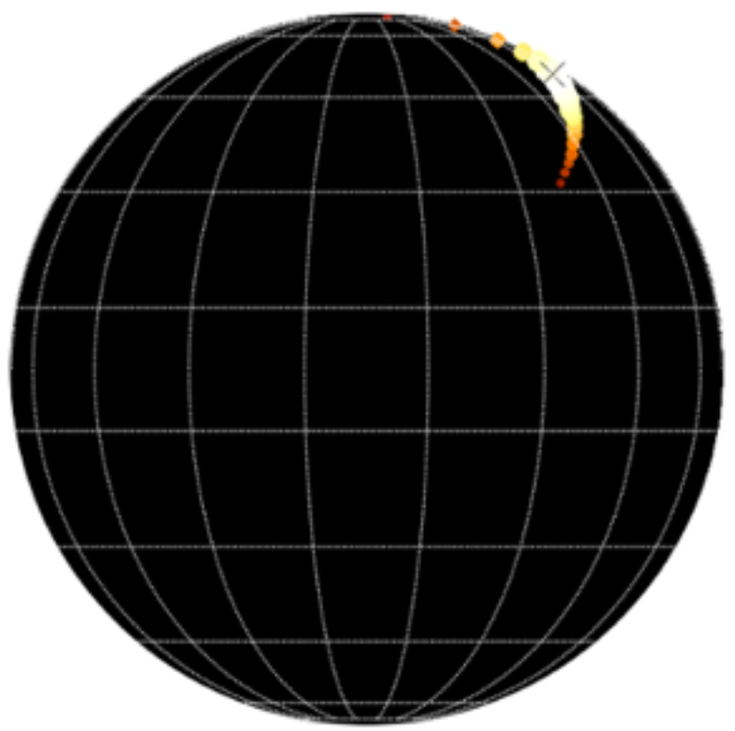


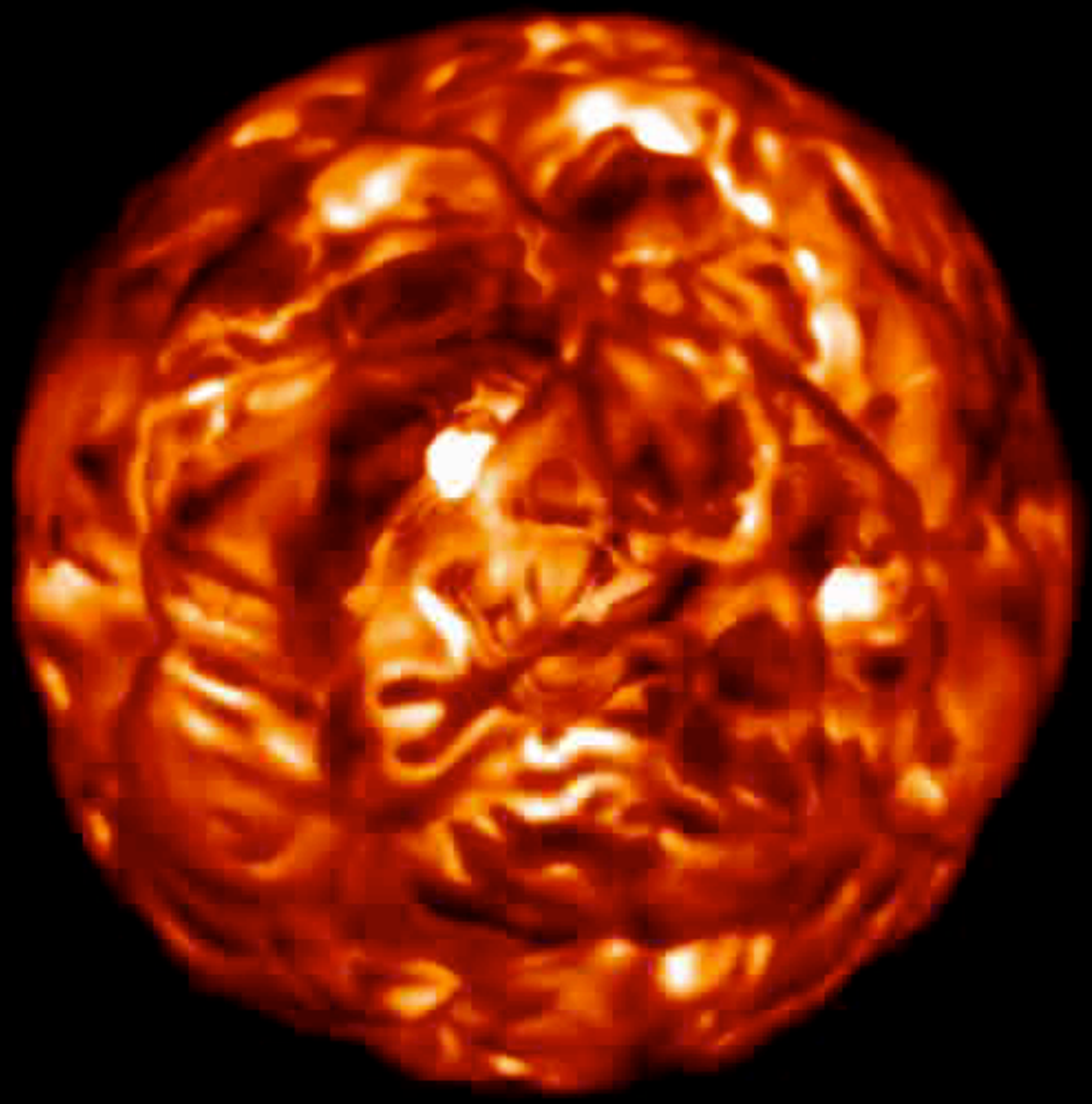
2014/01/09





2014/11/20





Second approximation:

Disk-integrated brightness distribution

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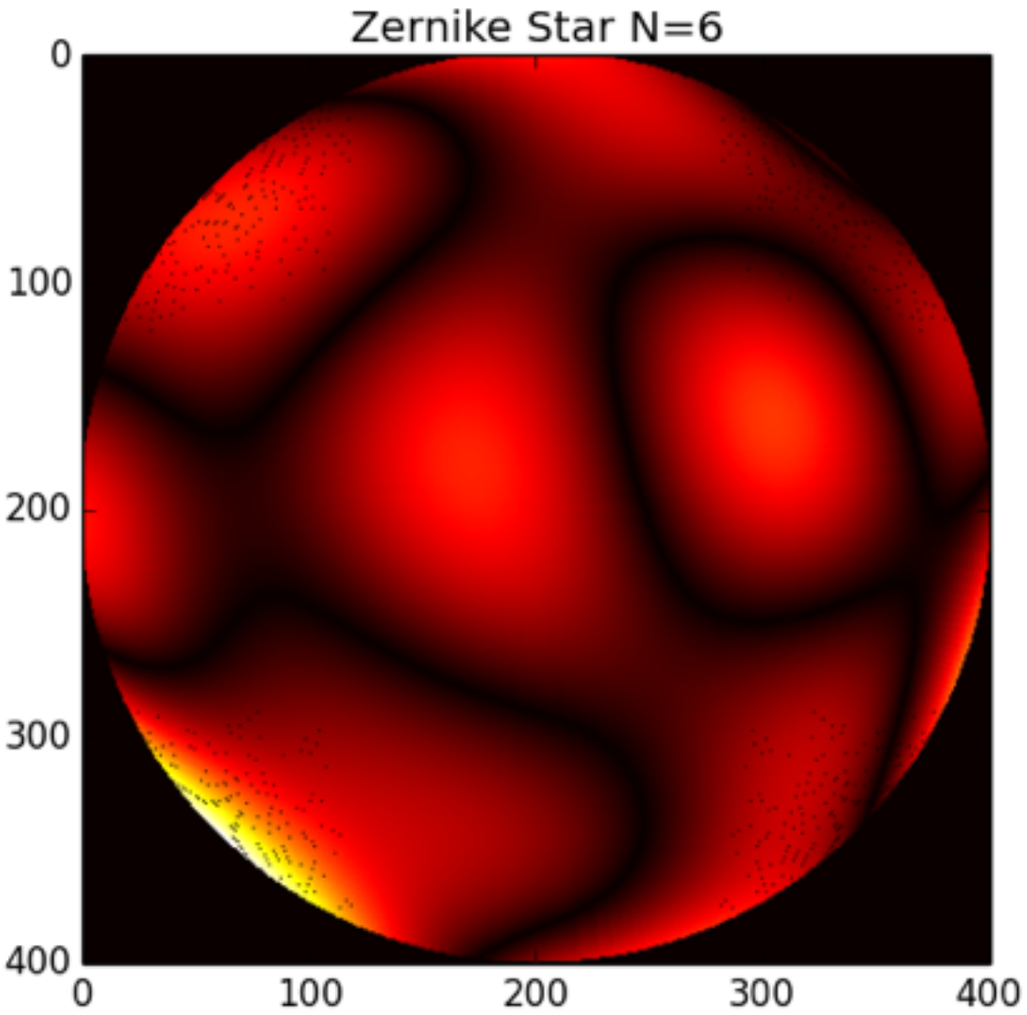
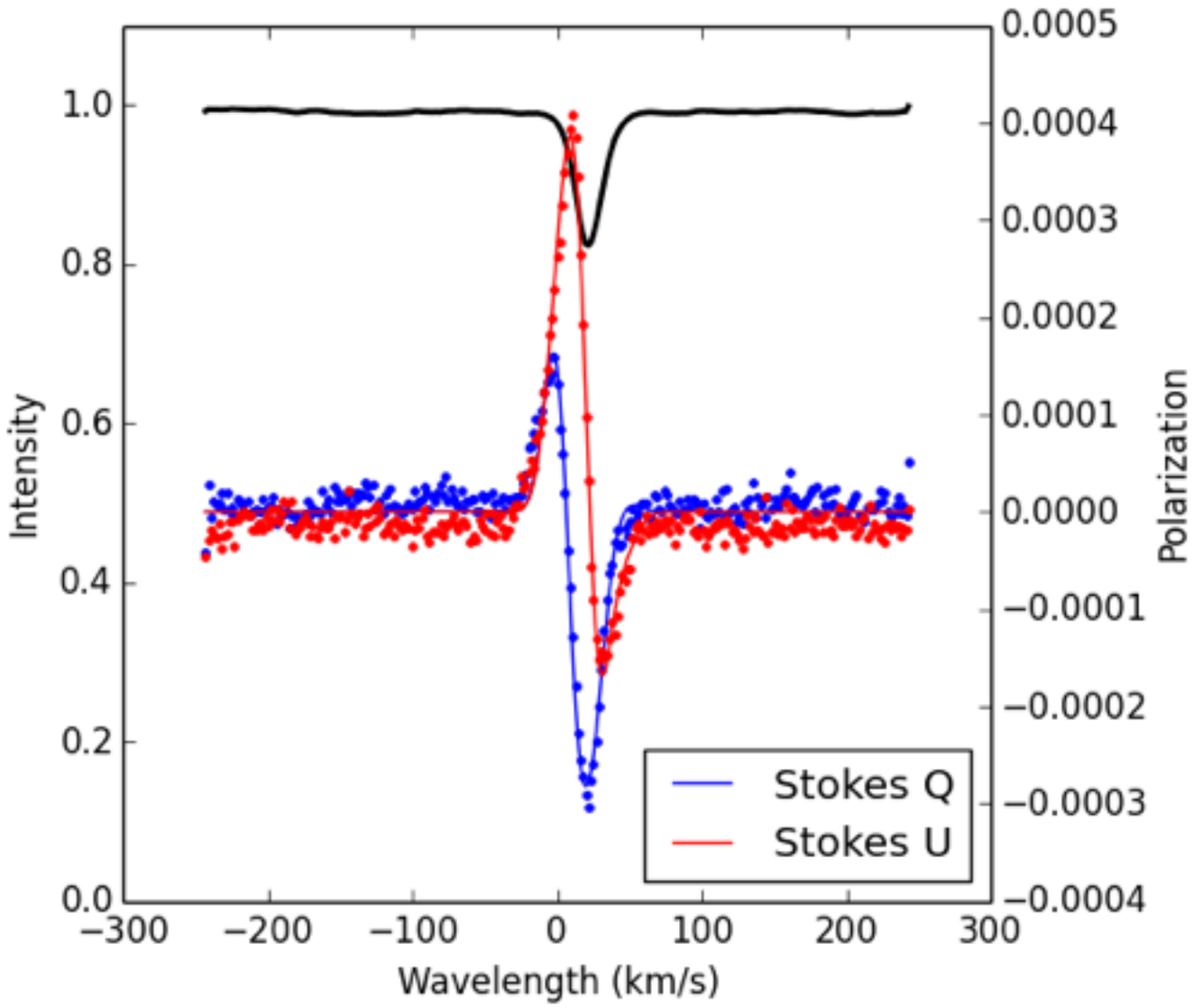
2014/10/16





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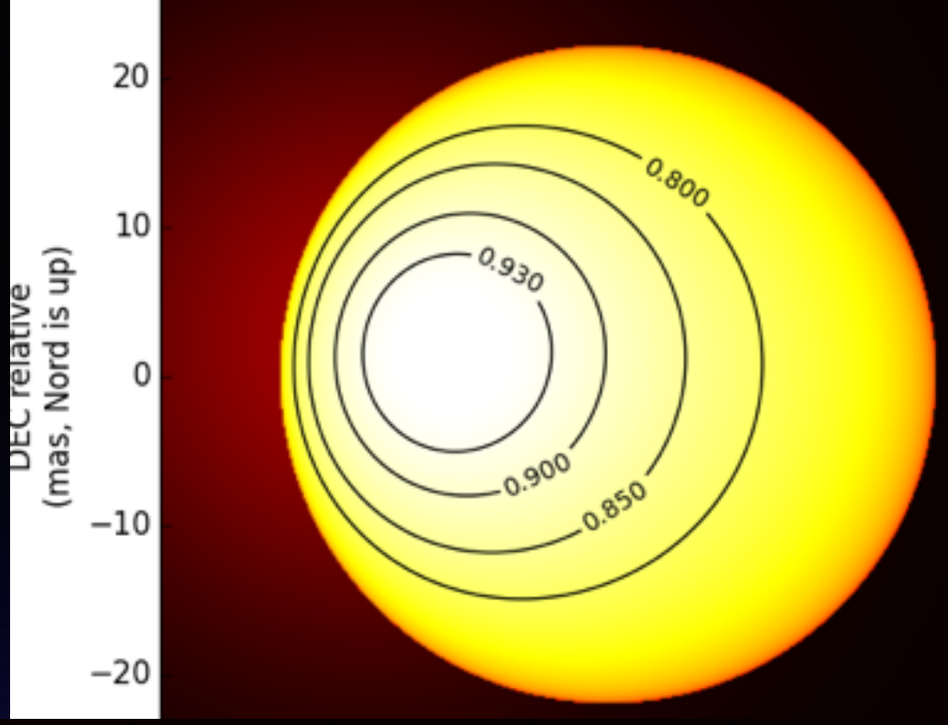
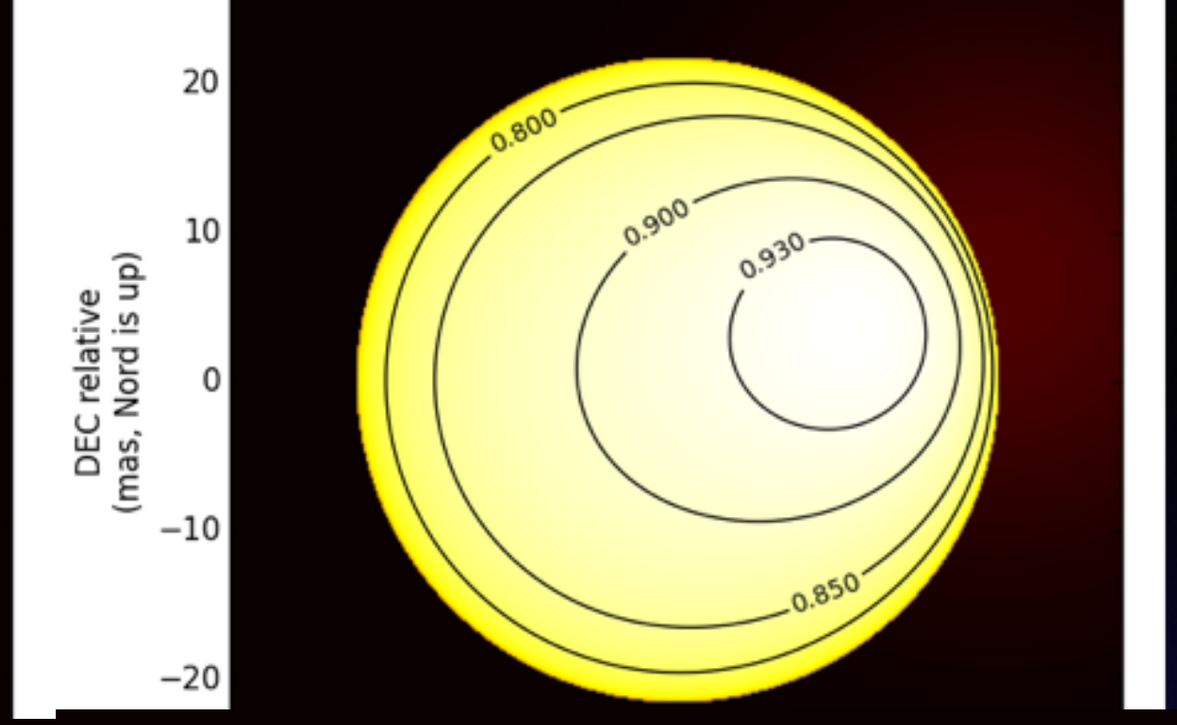
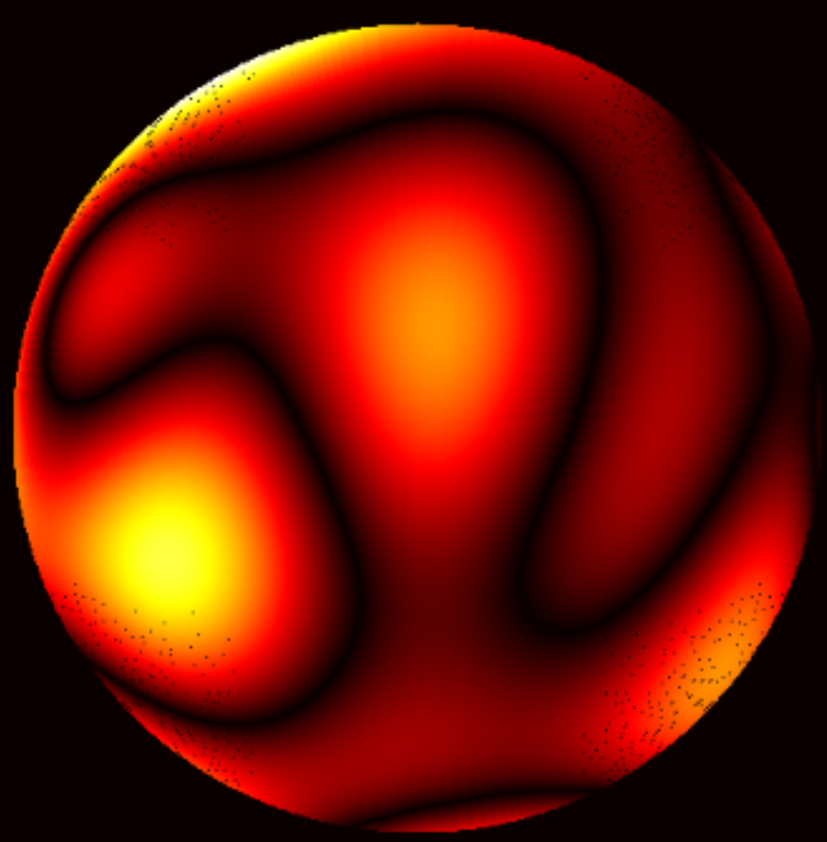
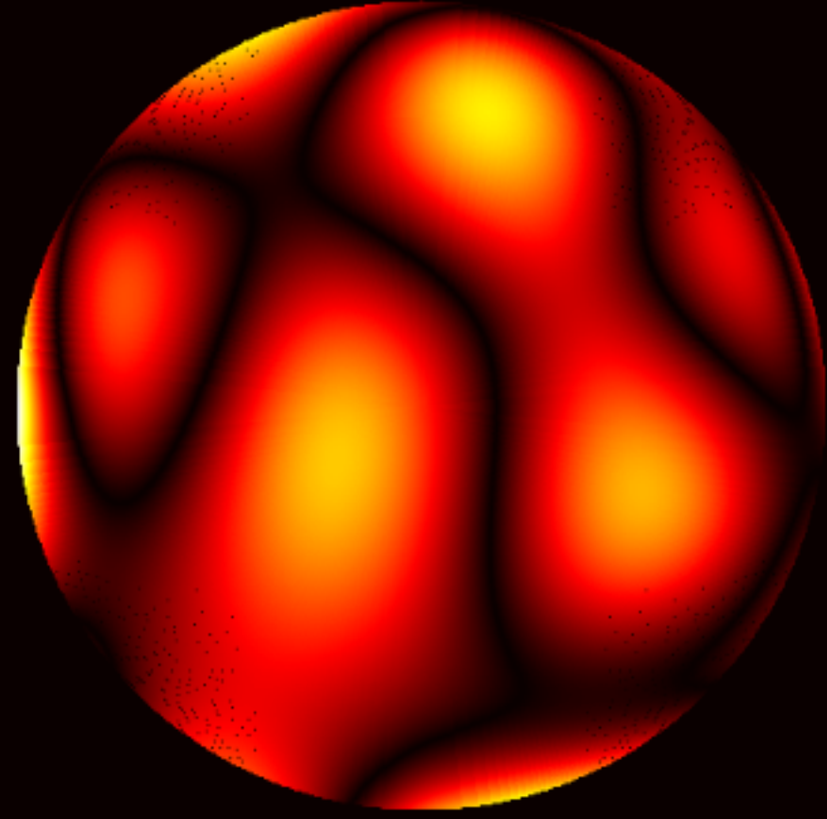




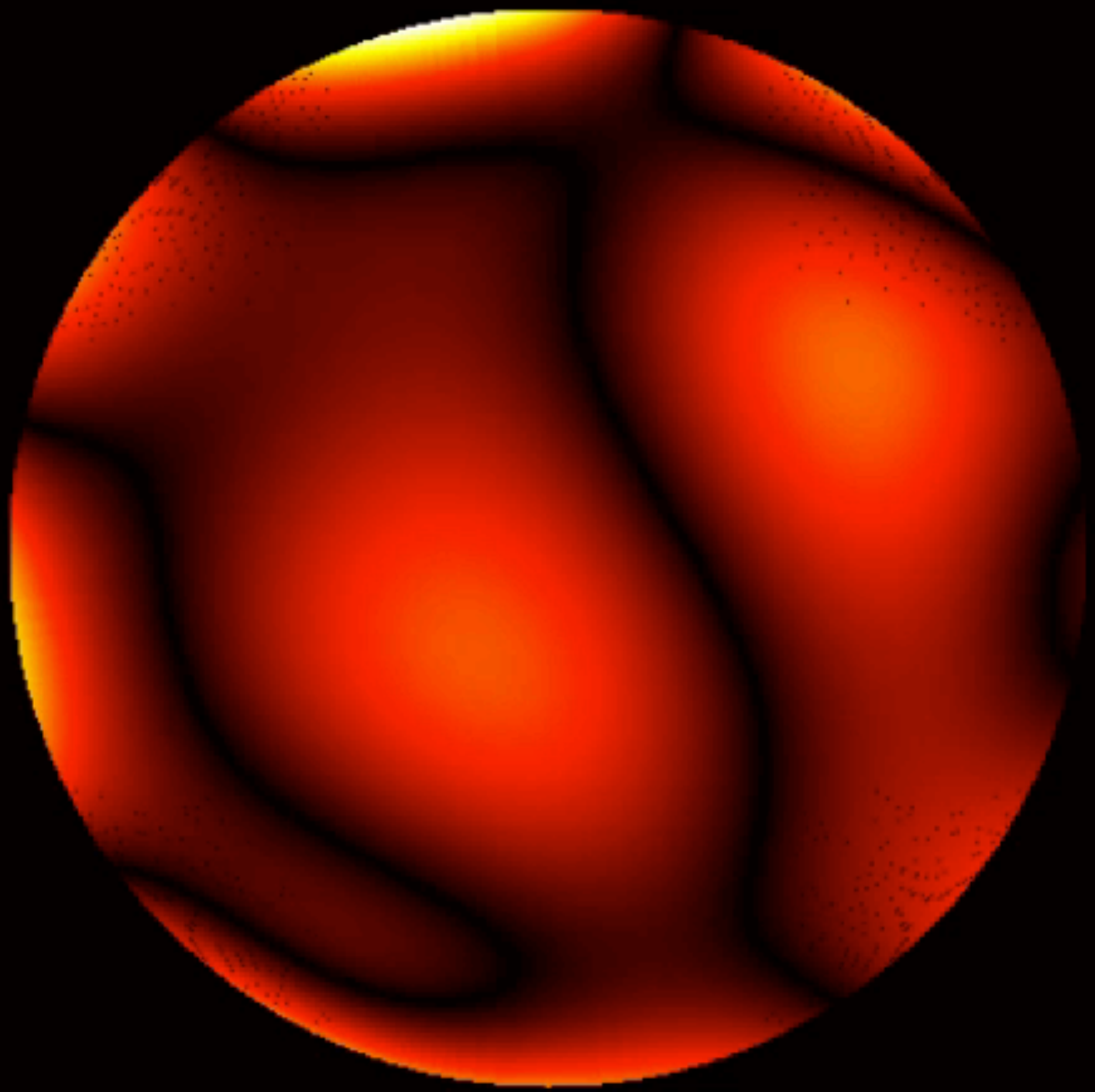
2014/01/09

2014/11/20





27/11/2013

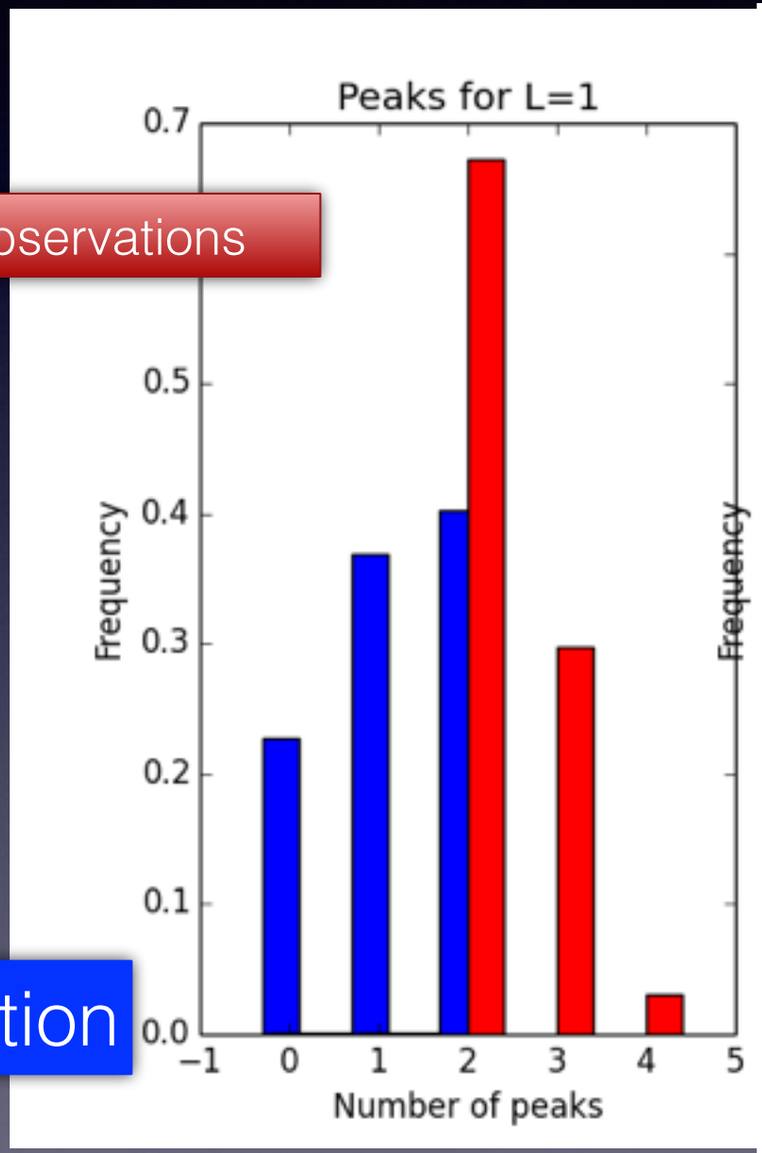


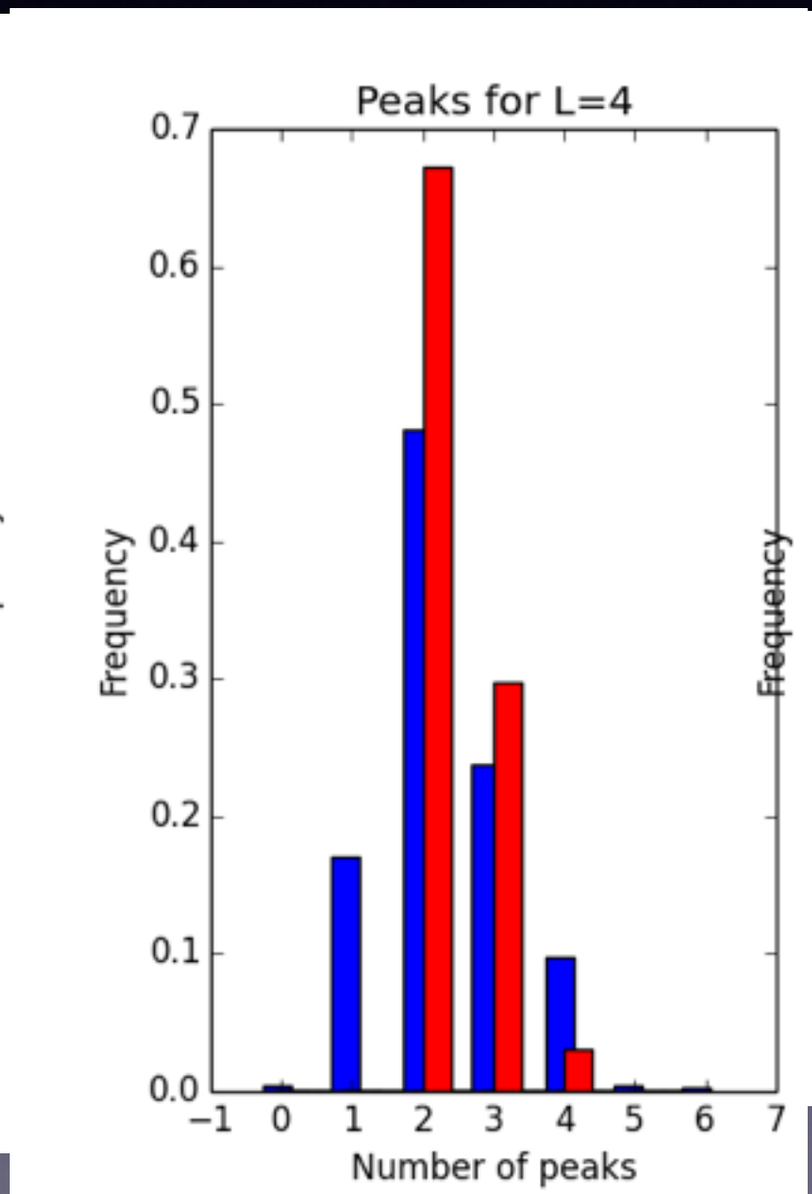
Size of convection cells

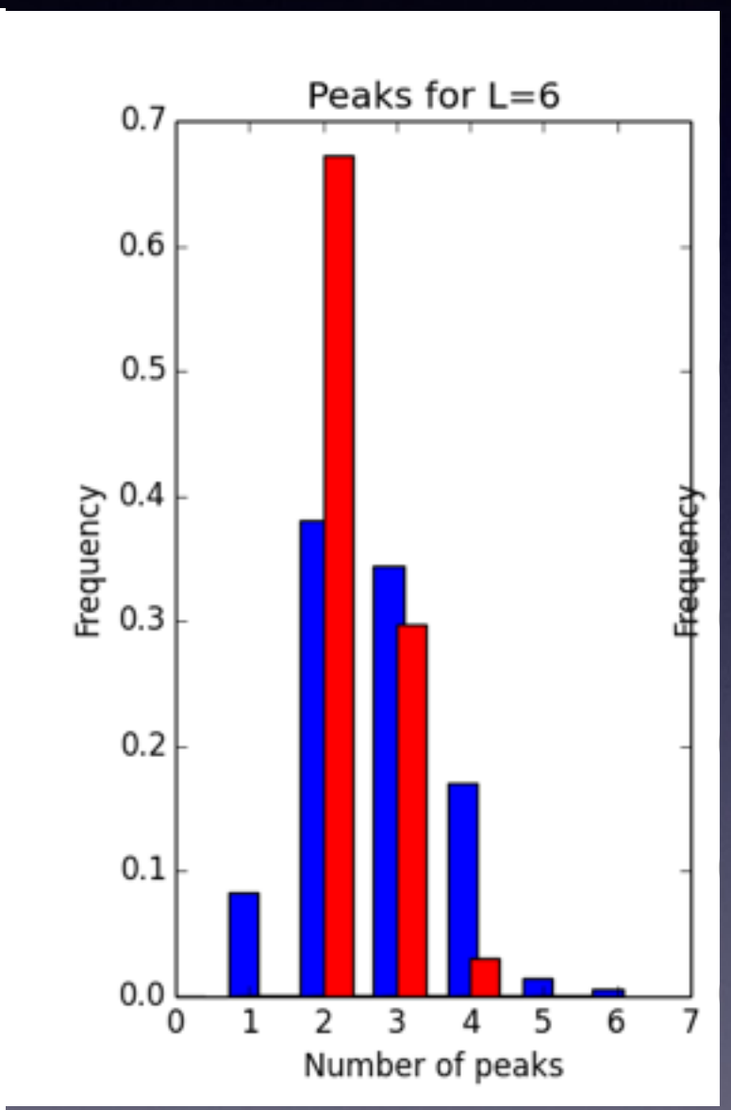
(Summer work of N. Ikhenache, M2 Lyon)

Observations

Simulation







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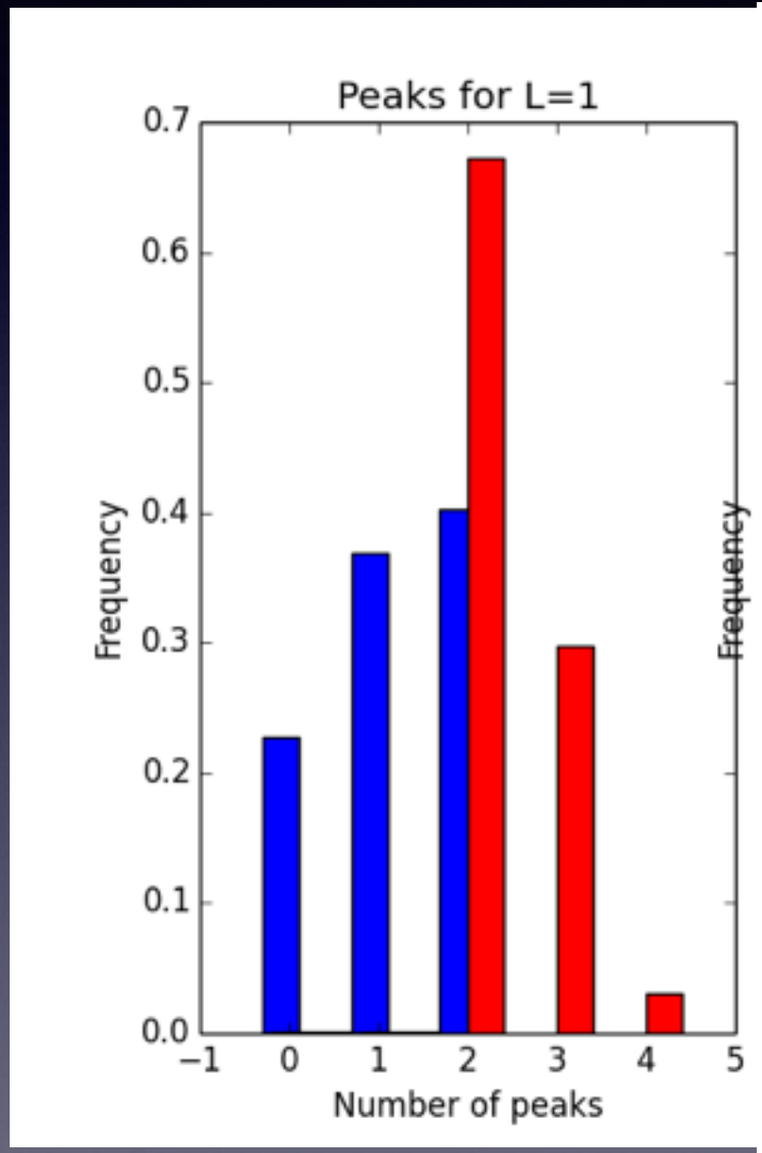
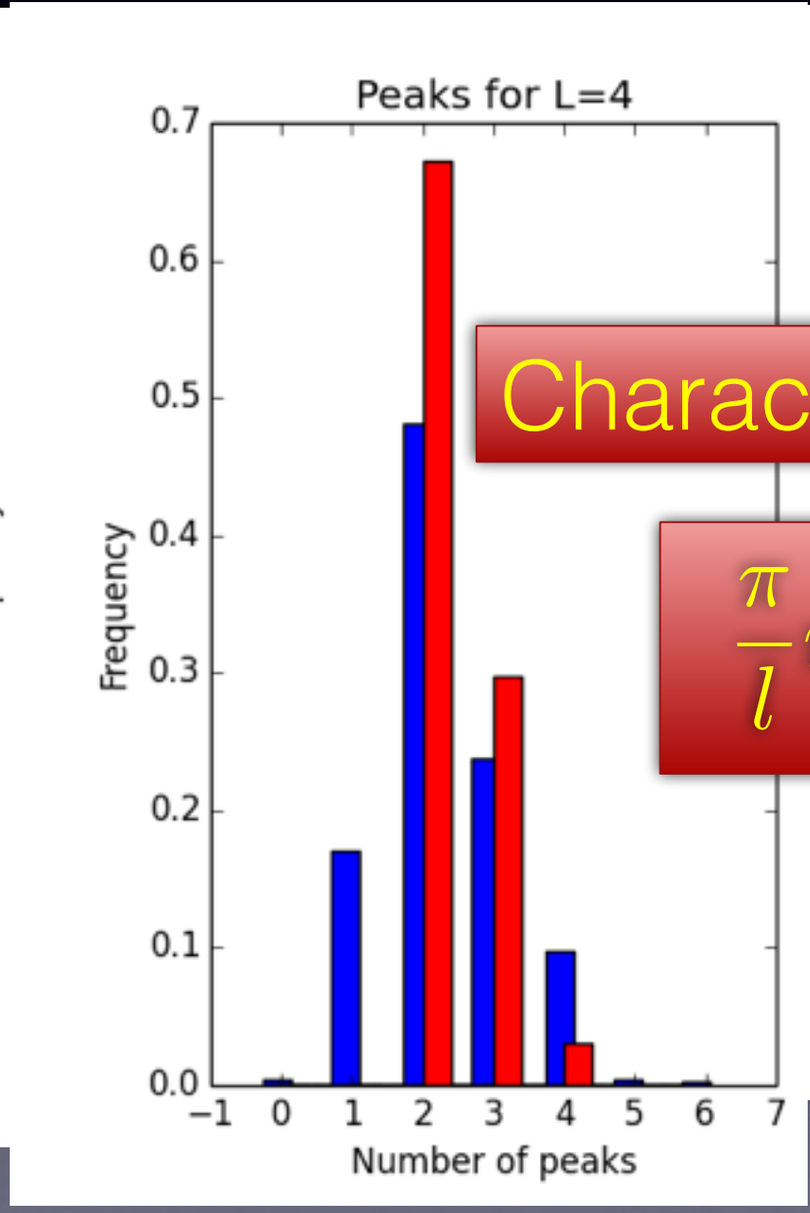
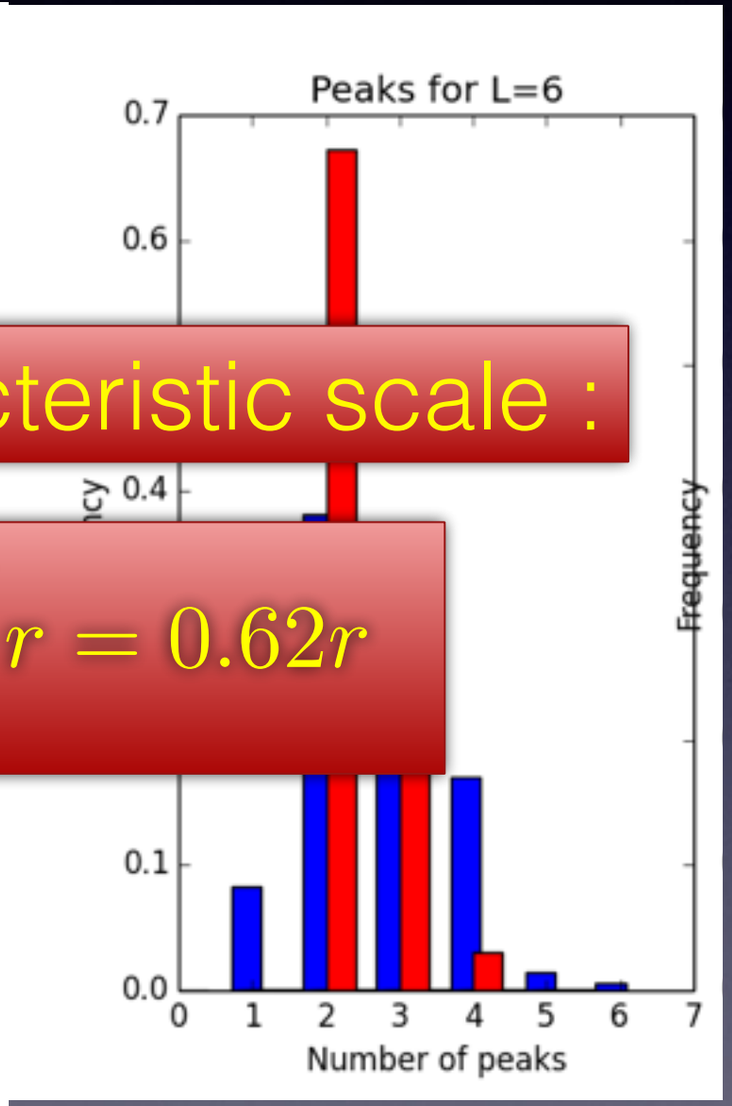
Size of convection cells

(Summer work of N. Ikhenache, M2 Lyon)



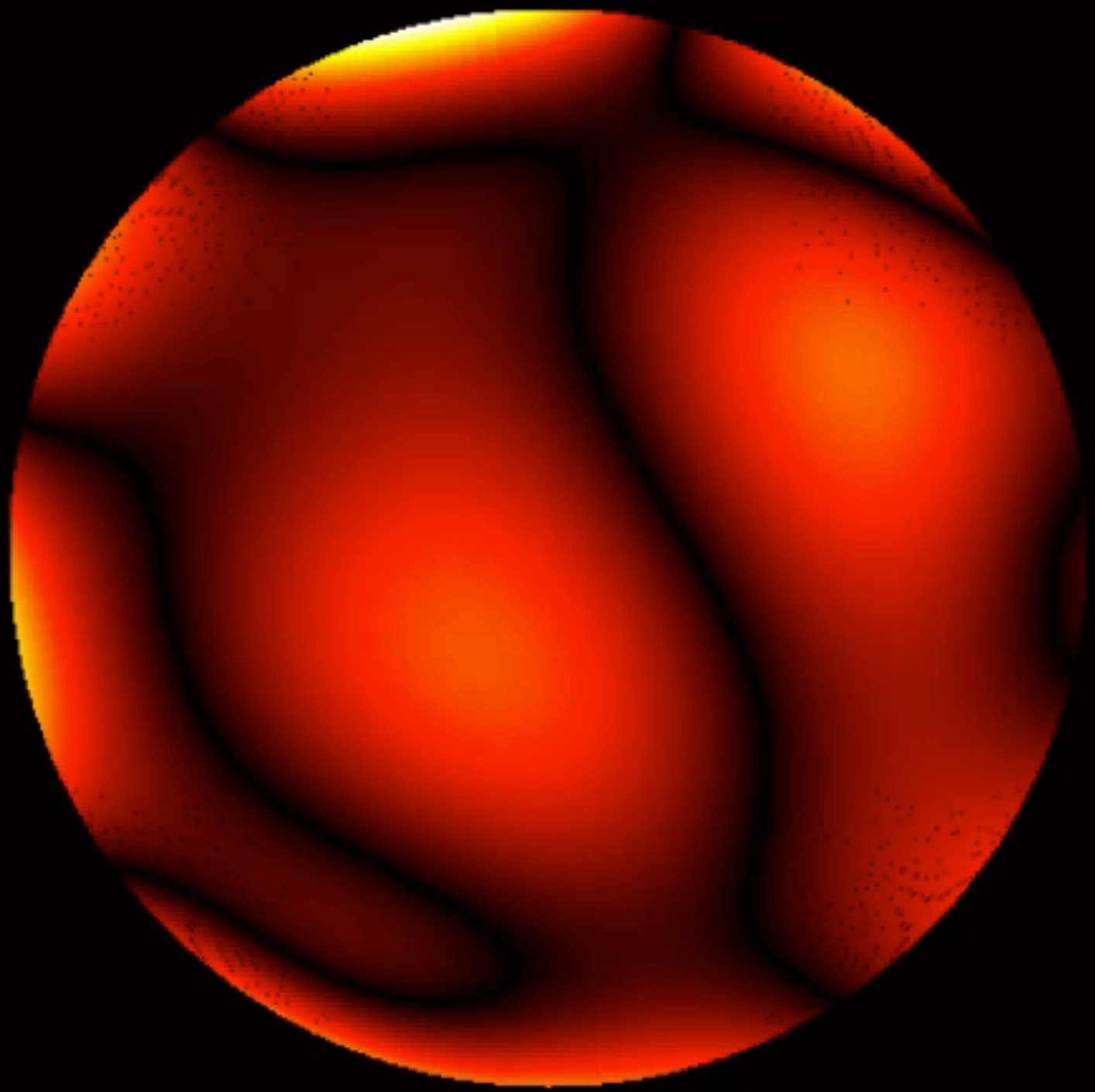




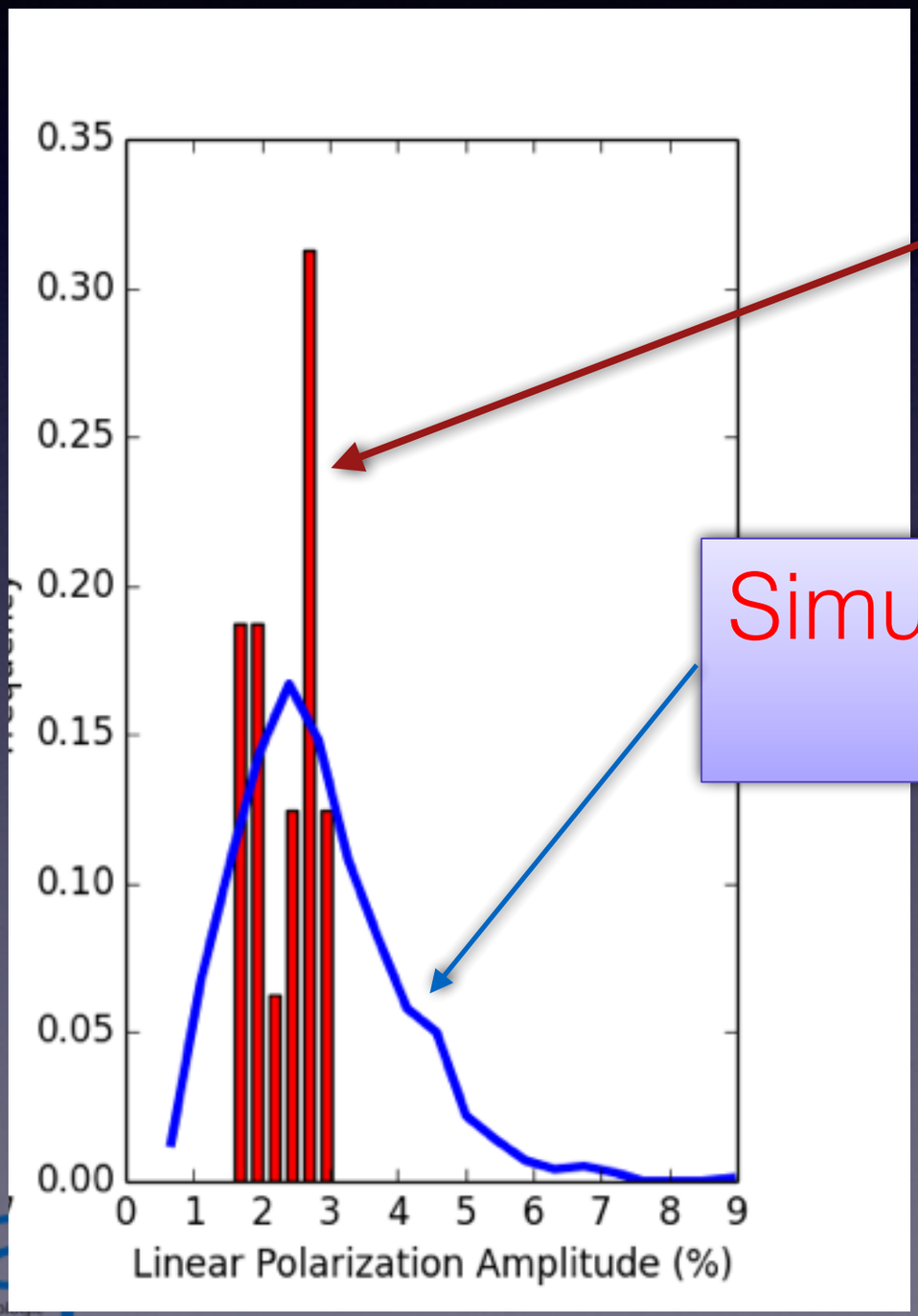
Characteristic scale :

$$\frac{\pi}{l} r = 0.62 r$$

27/11/2013



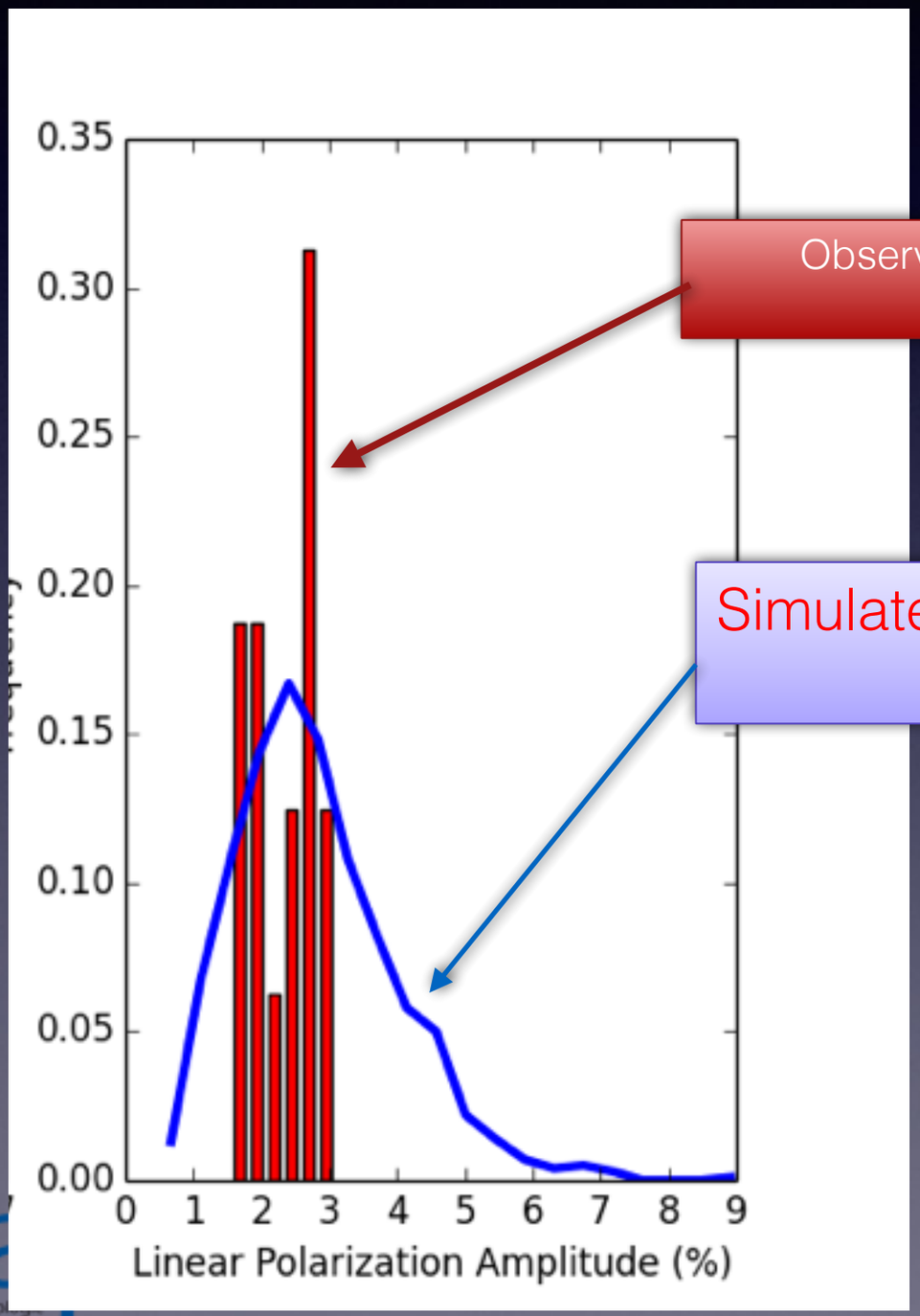
Polarization of the continuum
(Summer work of N. Ikhenache, M2 Lyon)



Observed Polarization
x100

Simulated Polarization
x P_{cont}

Polarization of the continuum
(Summer work of N. Ikhenache, M2 Lyon)



$P_{cont} = 1\%$

Coincides with RT calculations of, e.g., Doherty (1986)

1st stage of wind acceleration

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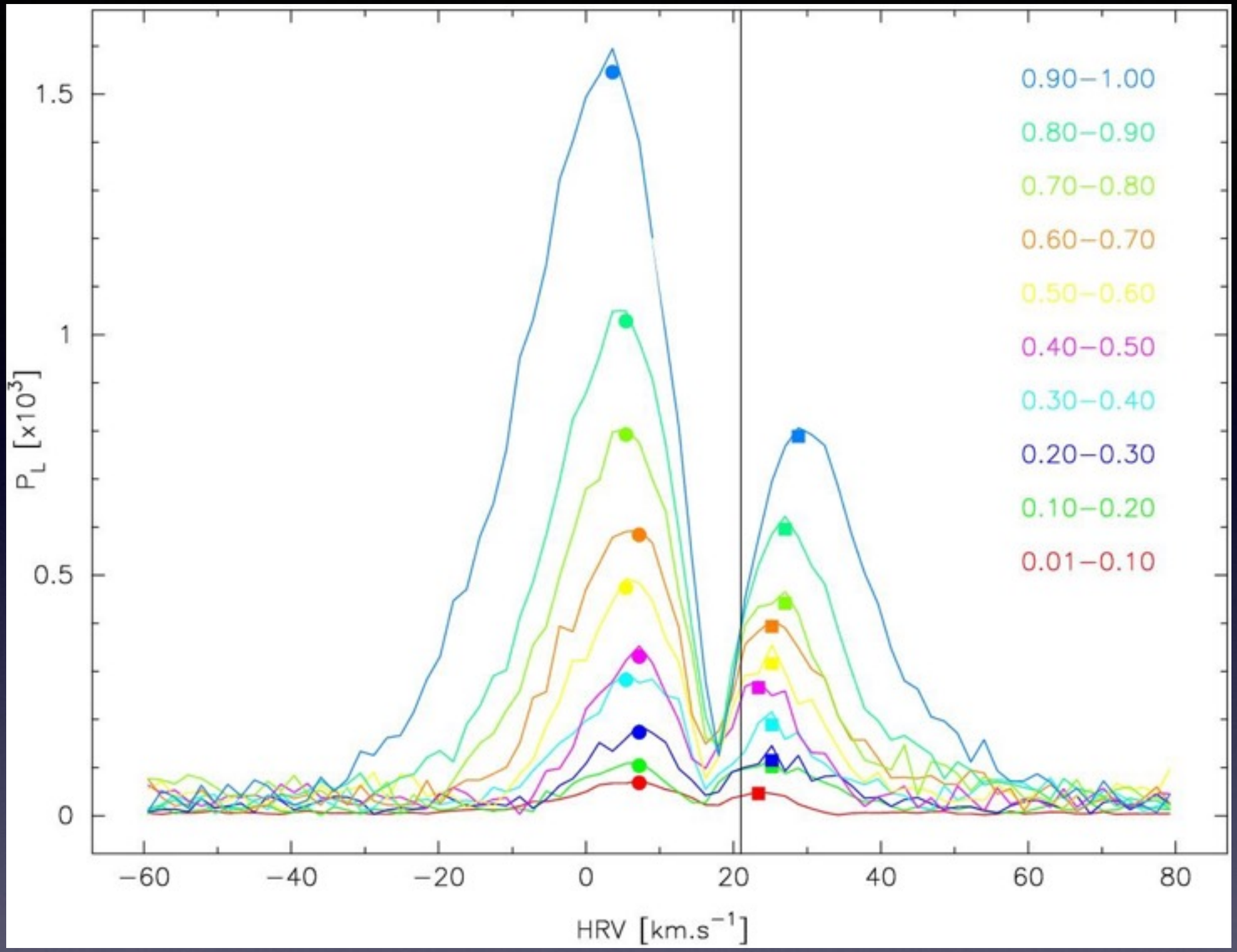

The deeper the line the higher the Doppler shift

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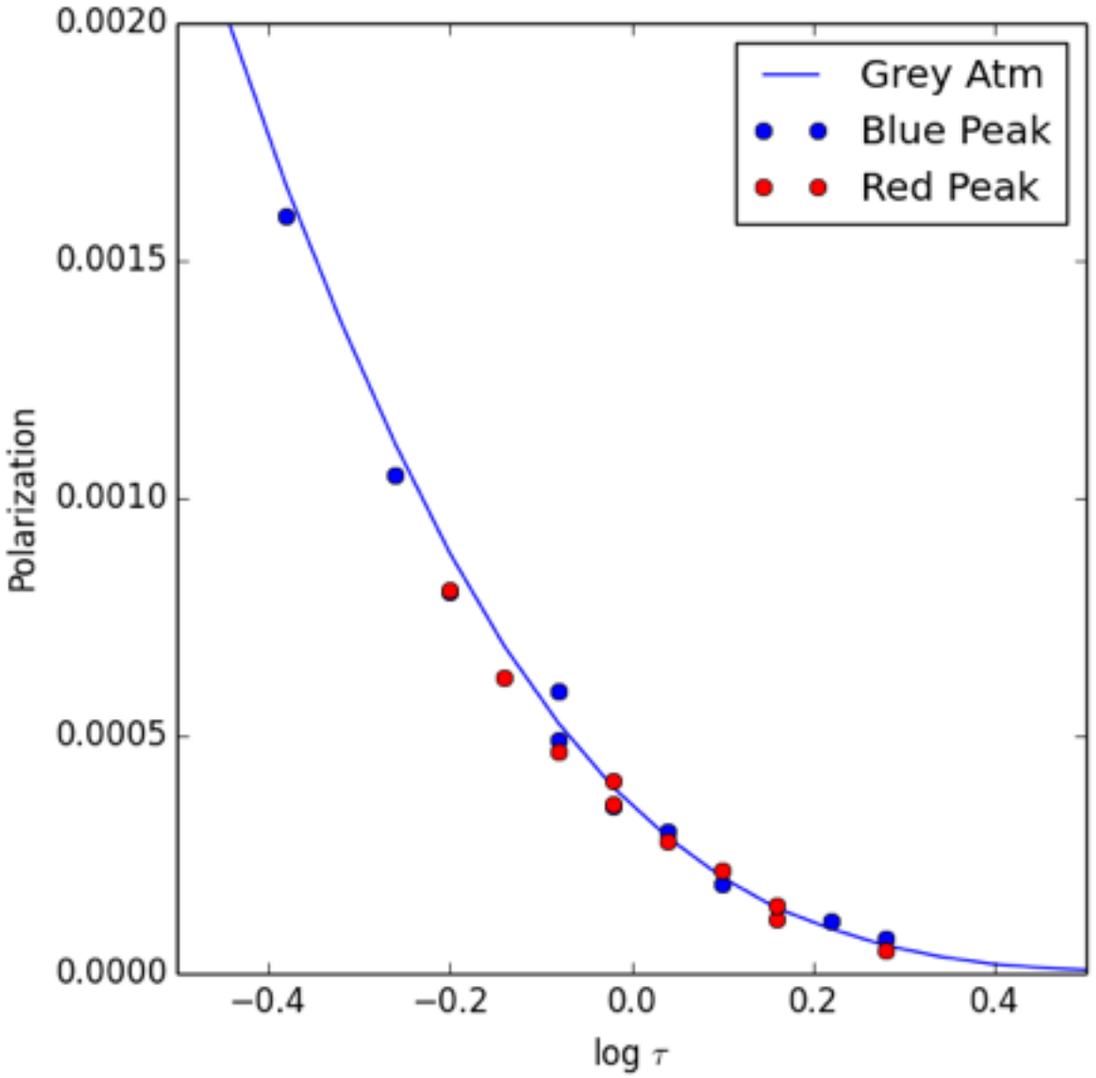

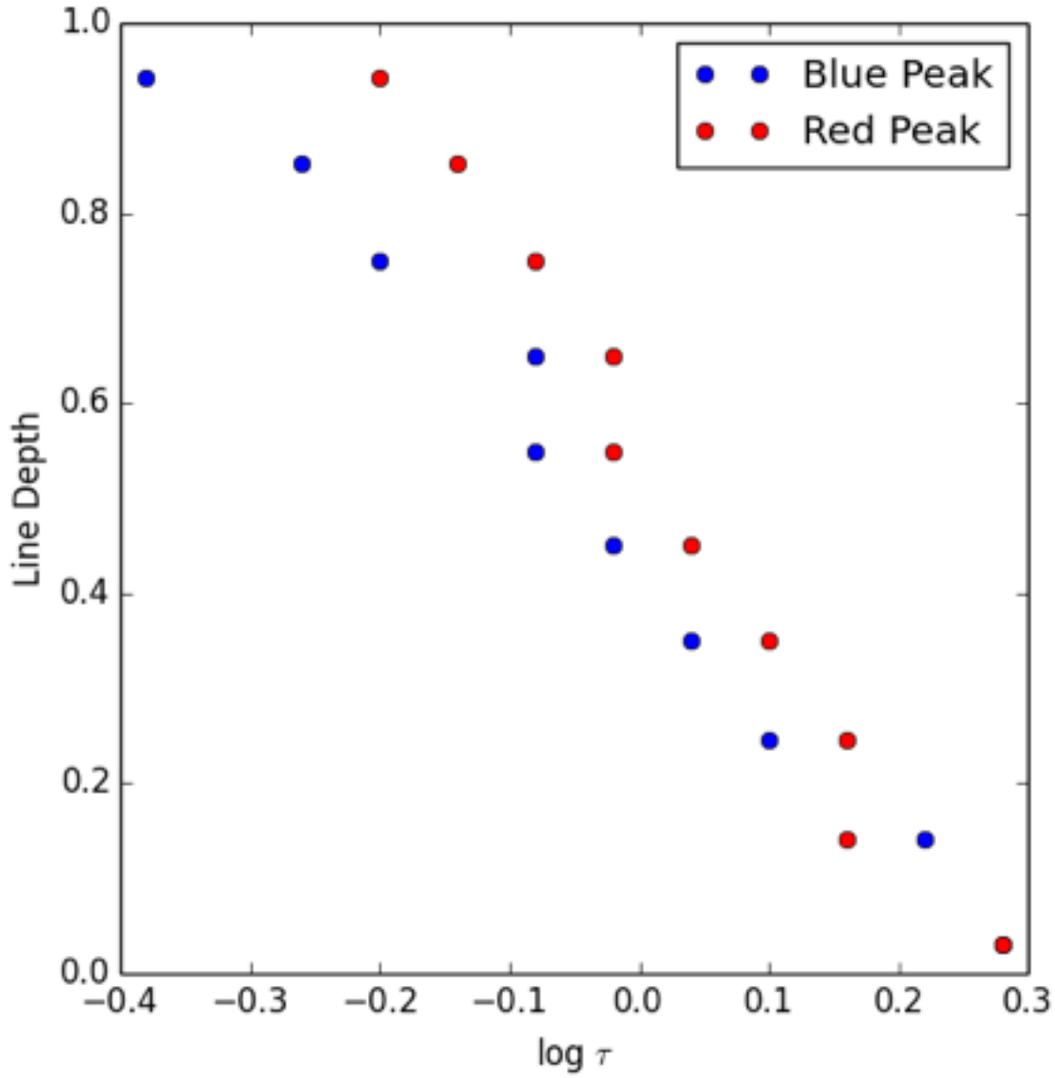

Deeper lines form higher and are depolarised further away from the star

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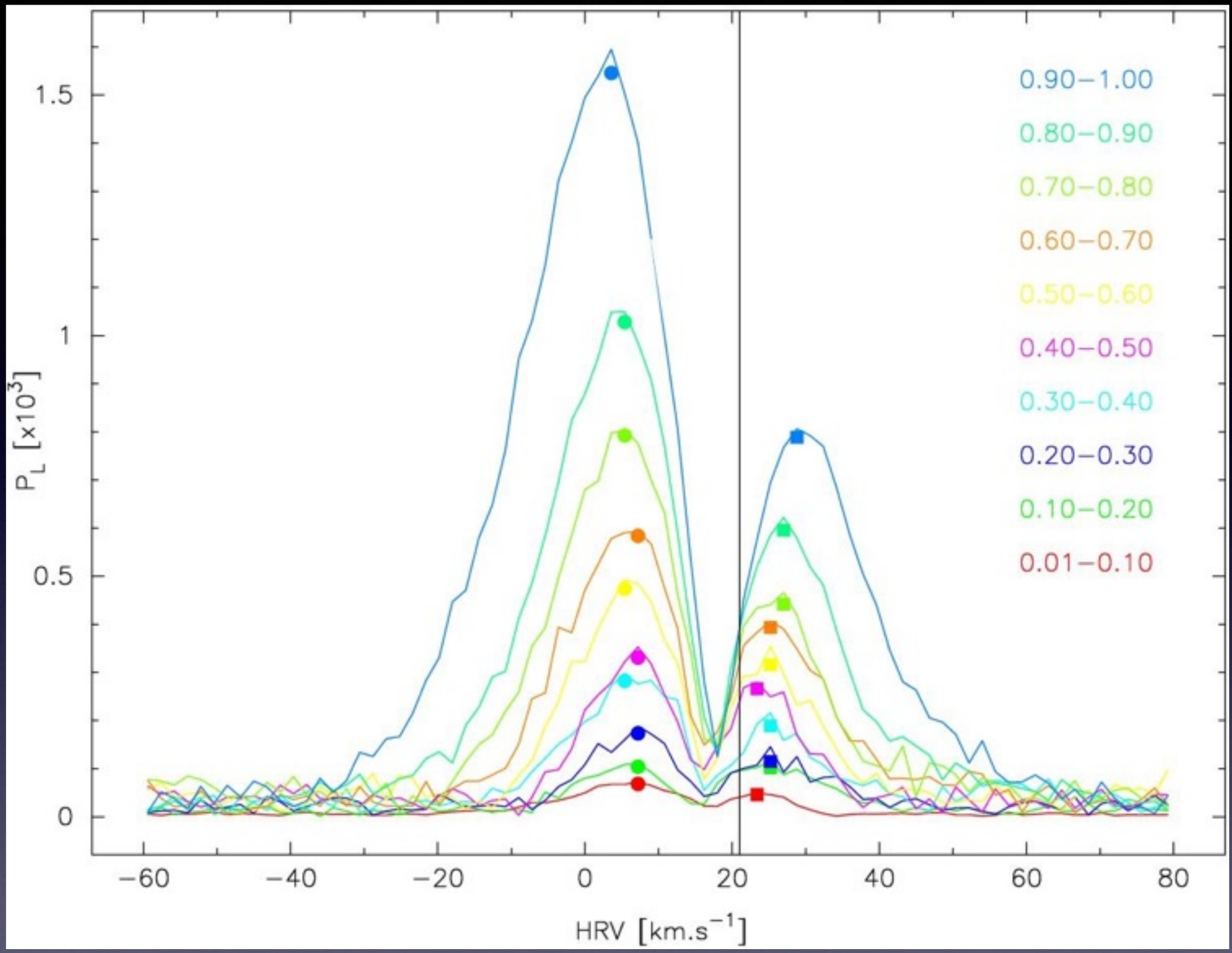

Hence, we measure an increasing velocity the higher the lines are formed

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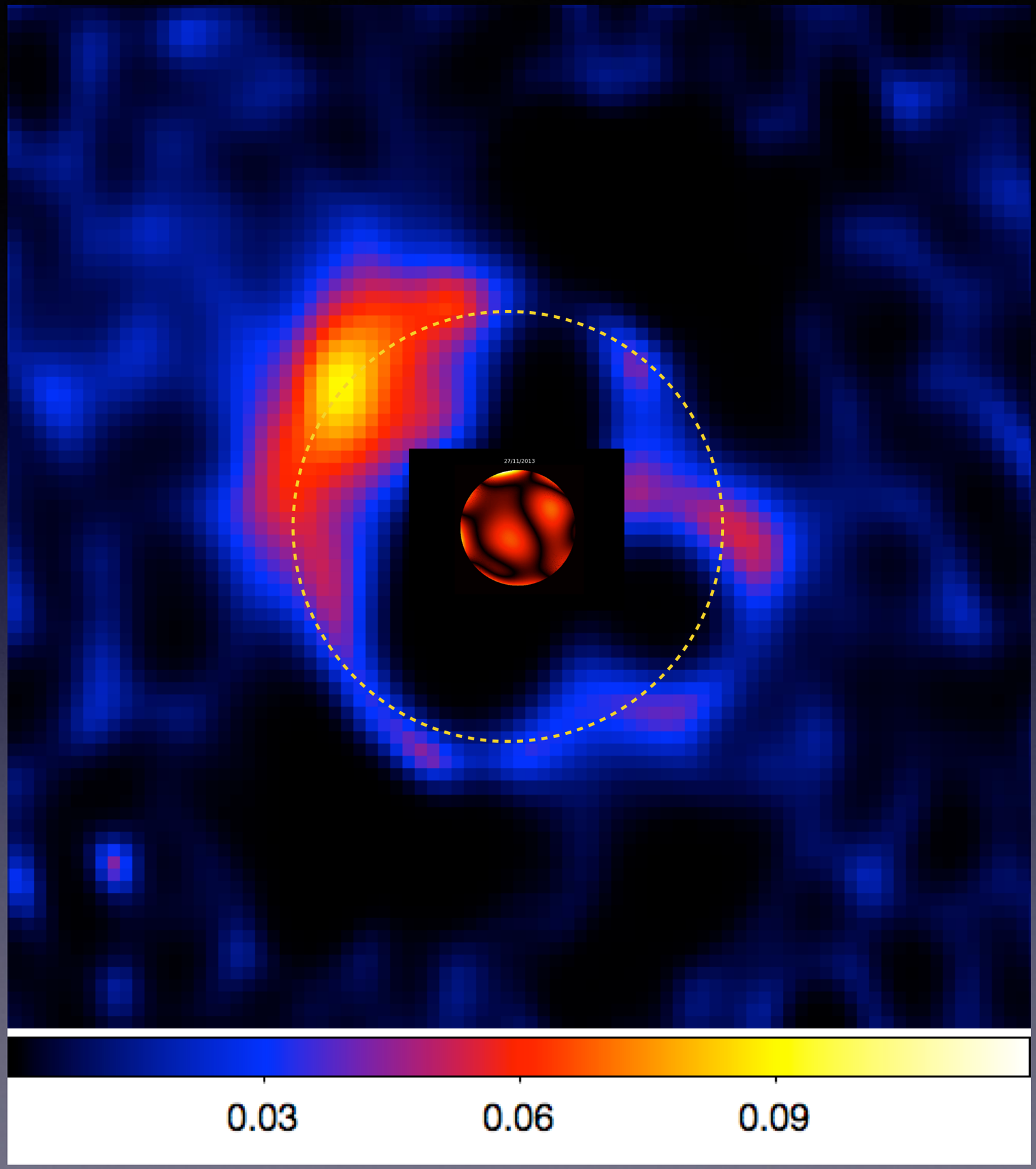
27/11/2013
0.03
0.06
0.09