THE He I 10830 Å TRIPLET:

A TOOL FOR UNDERSTANDING CHROMOSPHERIC MAGNETISM

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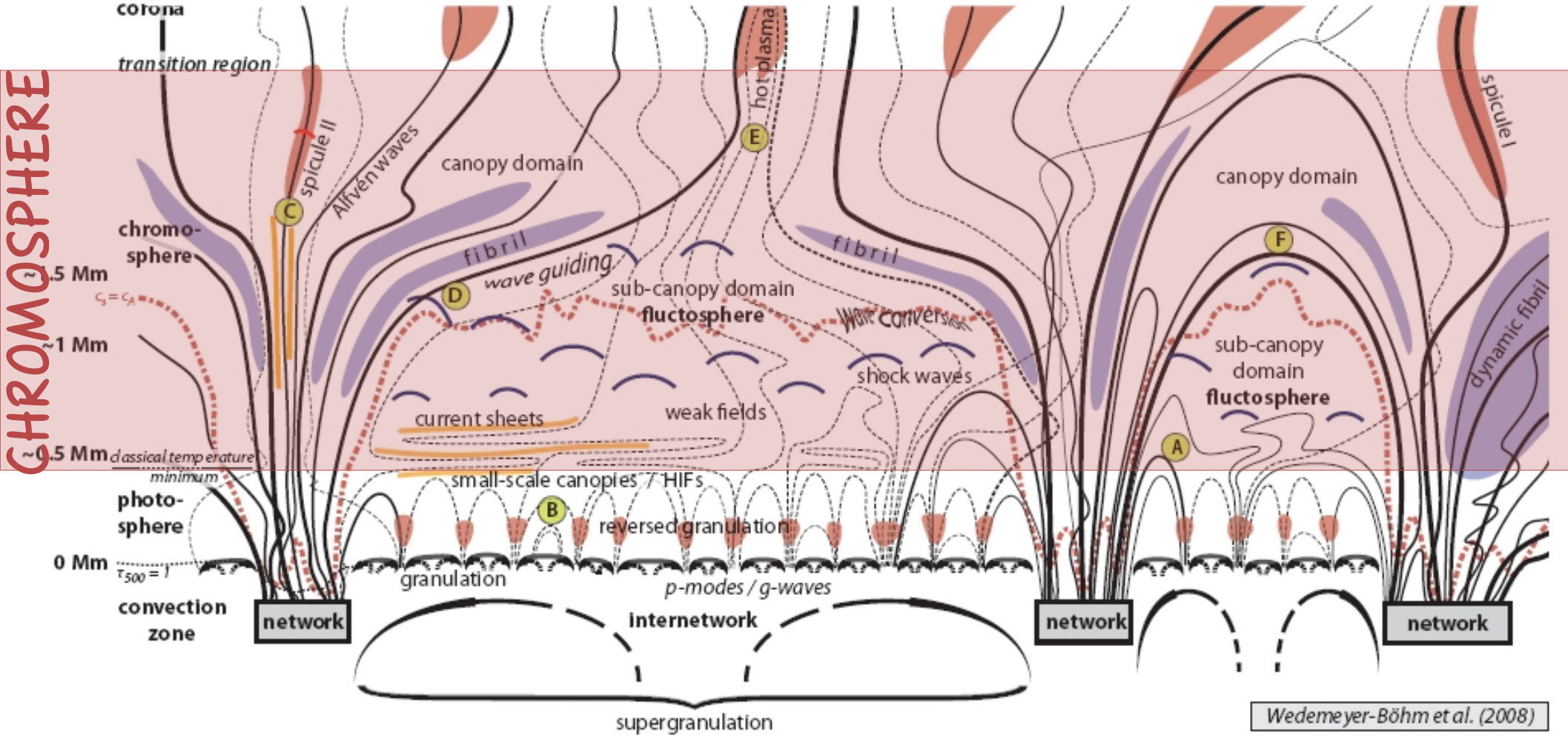
Introduction



Wedemeyer-Böhm et al. 2008

Chromospheric diagnostics

Some typical chromospheric indicators:
H_α, Ca II H & K, Ca II IR triplet, Na D, Ly_α

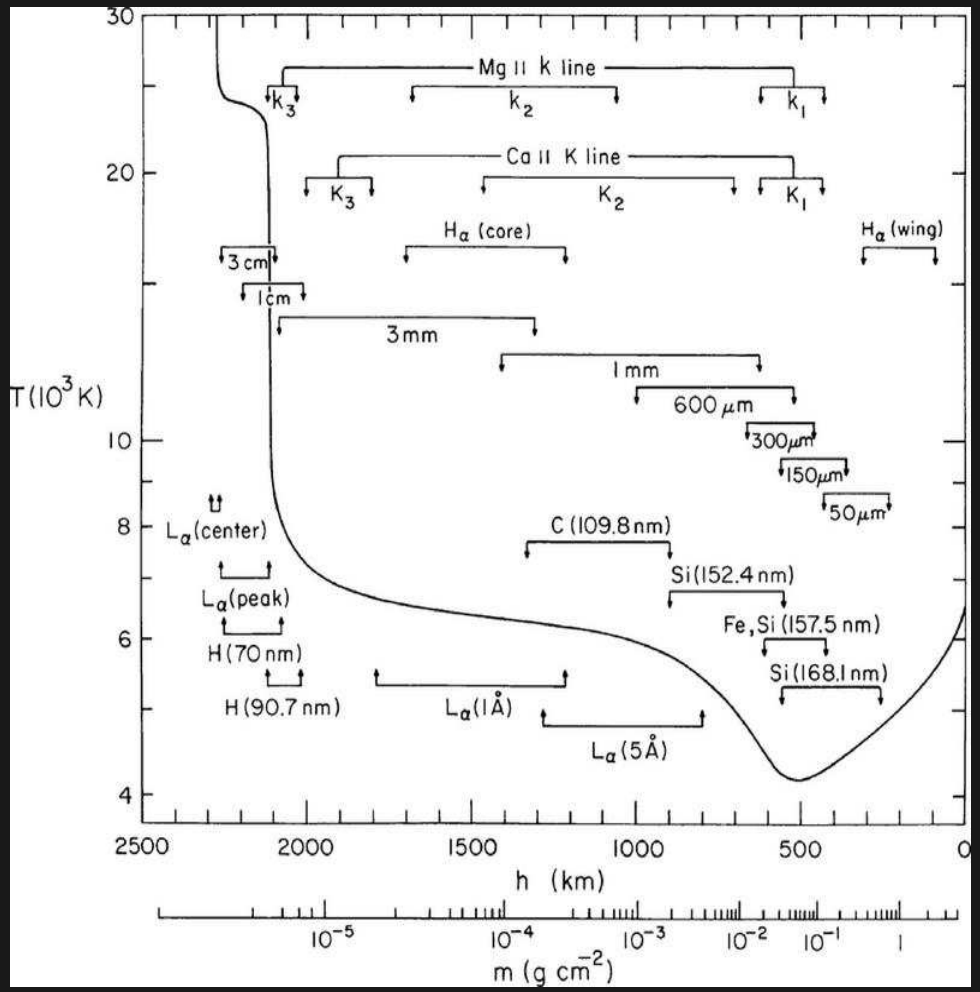
FILTERGRAMS – crosstalk among opacity, Doppler effects, temperature sensitivity. Photospheric leakage

Need for full spectral profile

PROXY MAGNETISM – crosstalk between temperature, magnetic field

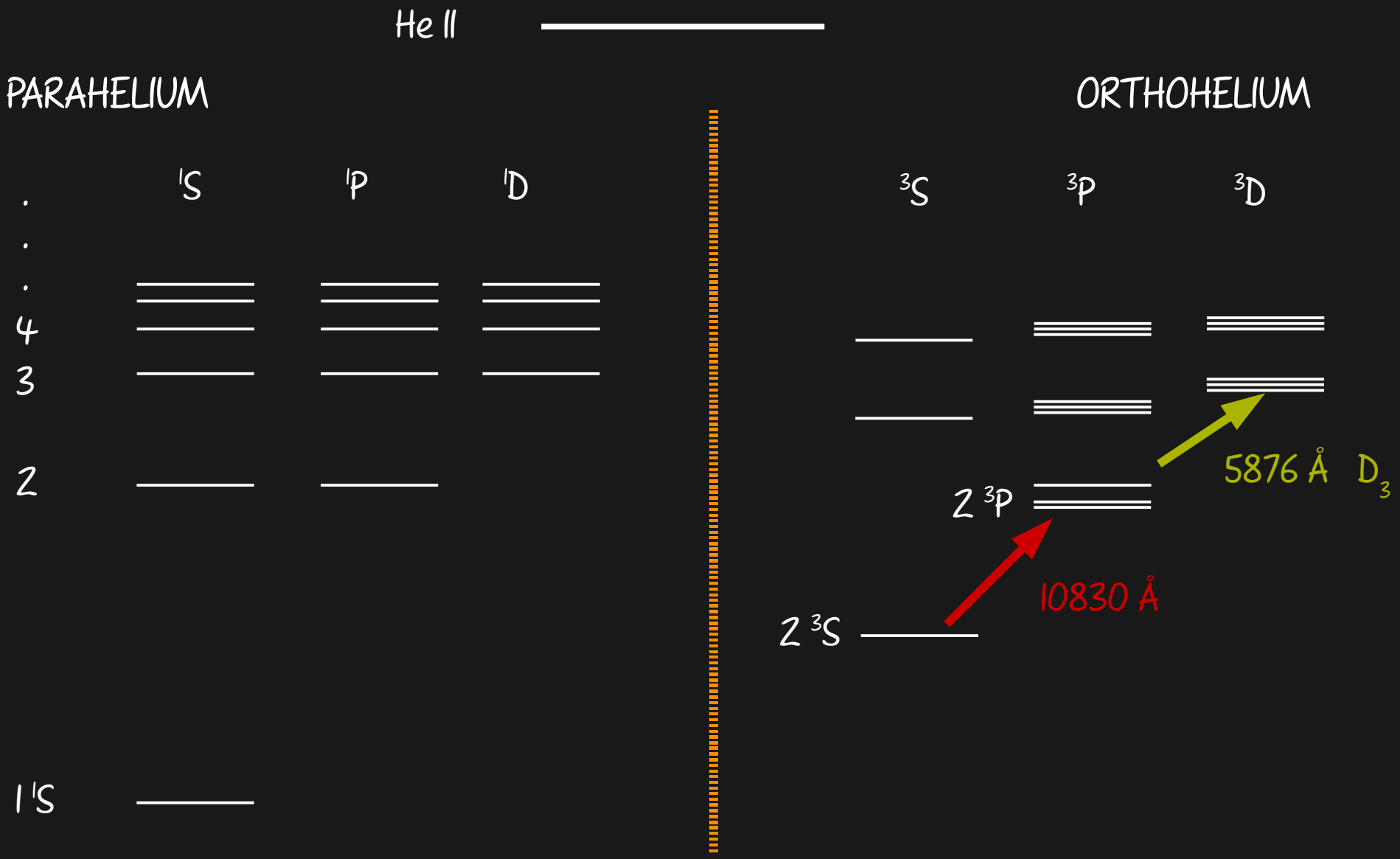
Need for full Stokes vector

LINE FORMATION -- very broad regions of the atmosphere in conditions that are very far from LTE



Spectral line forming regions, Vernazza et al. (1990)

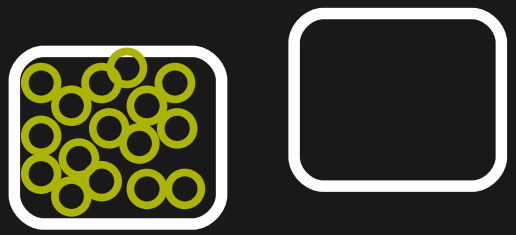
He I 10830 Å


He II
PARAHELIUM
ORTHOHELIUM
1S
1P
1D
3S
3P
3D
4
3
2
1 1S
2 3P
2 3S
5876 Å D3
10830 Å

Formation mechanism

Under normal chromospheric temperature conditions triplet states are not sufficiently populated

He II



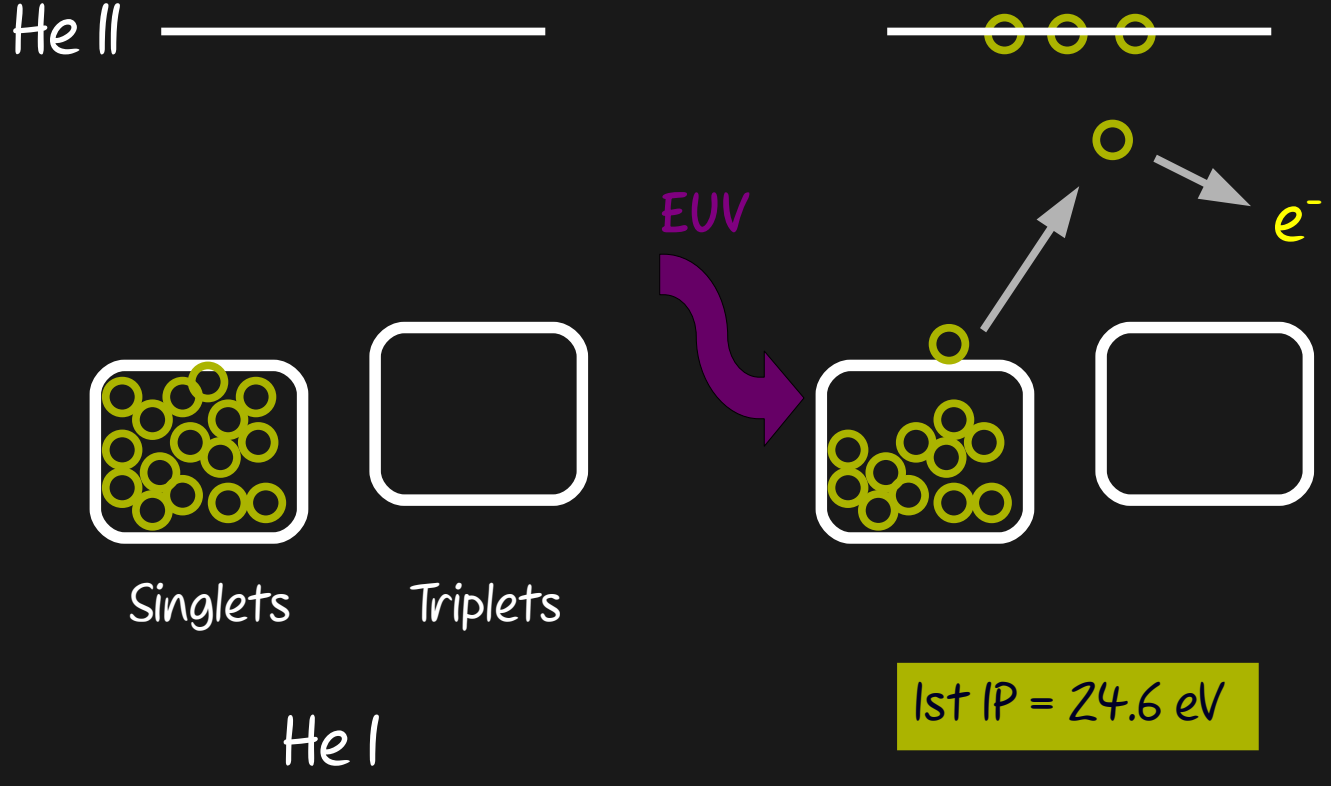
Singlets Triplets

He I

Formation mechanism

Under normal chromospheric temperature conditions triplet states are not sufficiently populated

Coronal EUV light triggers the PR mechanism ...

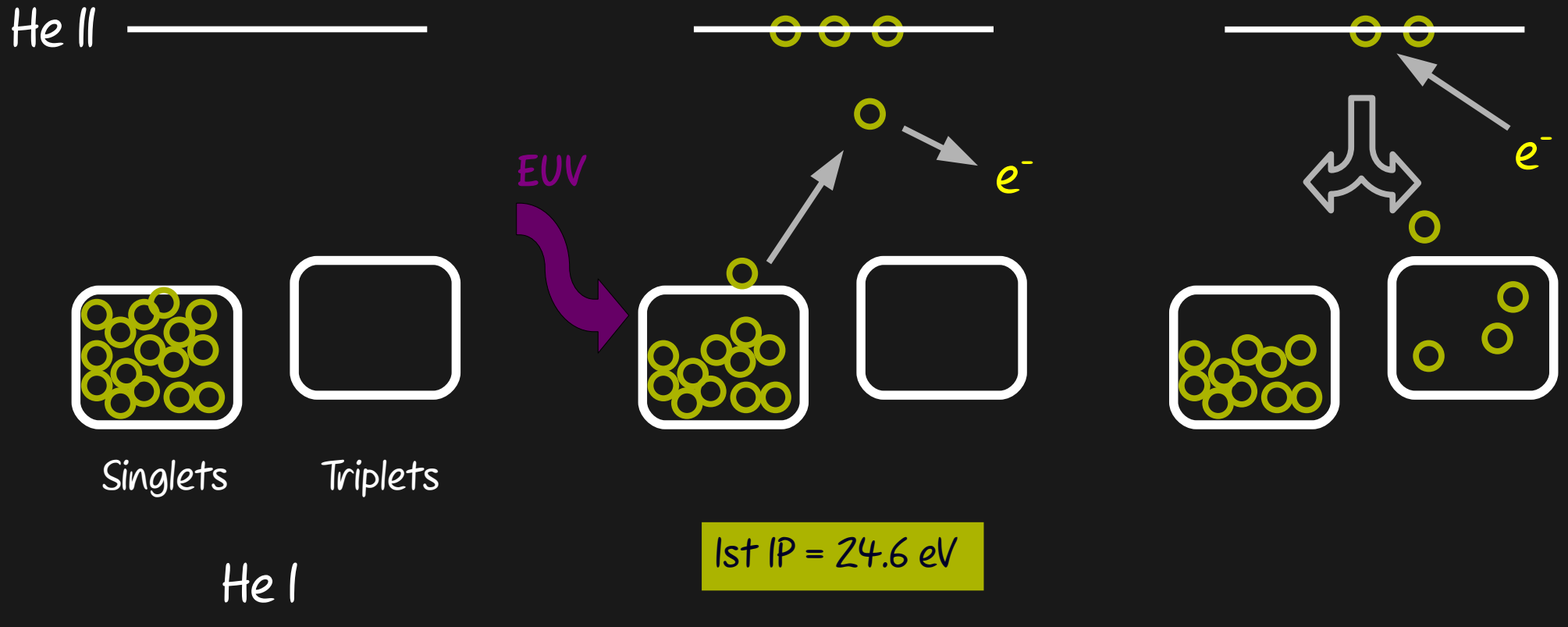


Formation mechanism

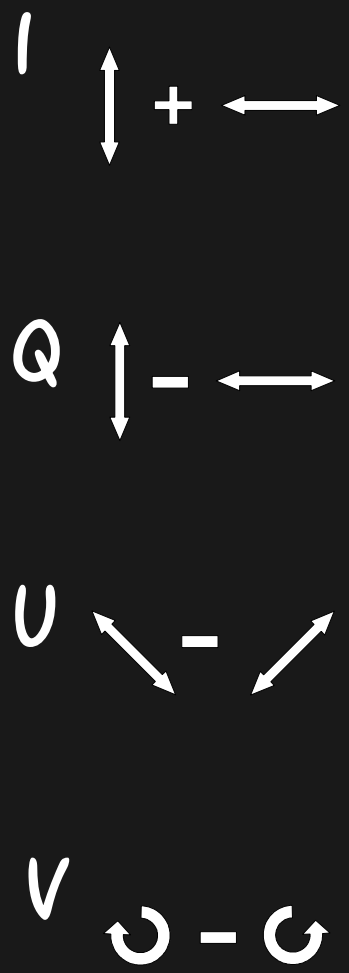
Under normal chromospheric temperature conditions triplet states are not sufficiently populated

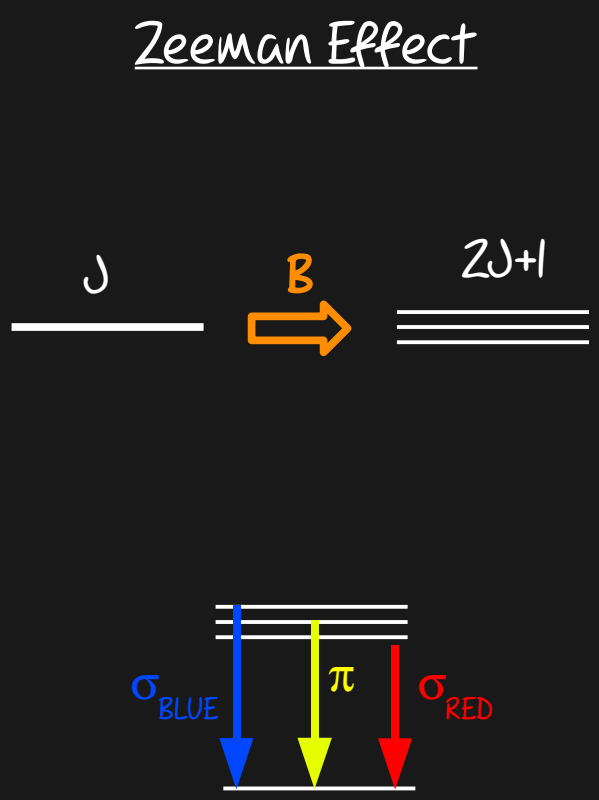
Coronal EUV light triggers the PR mechanism ...

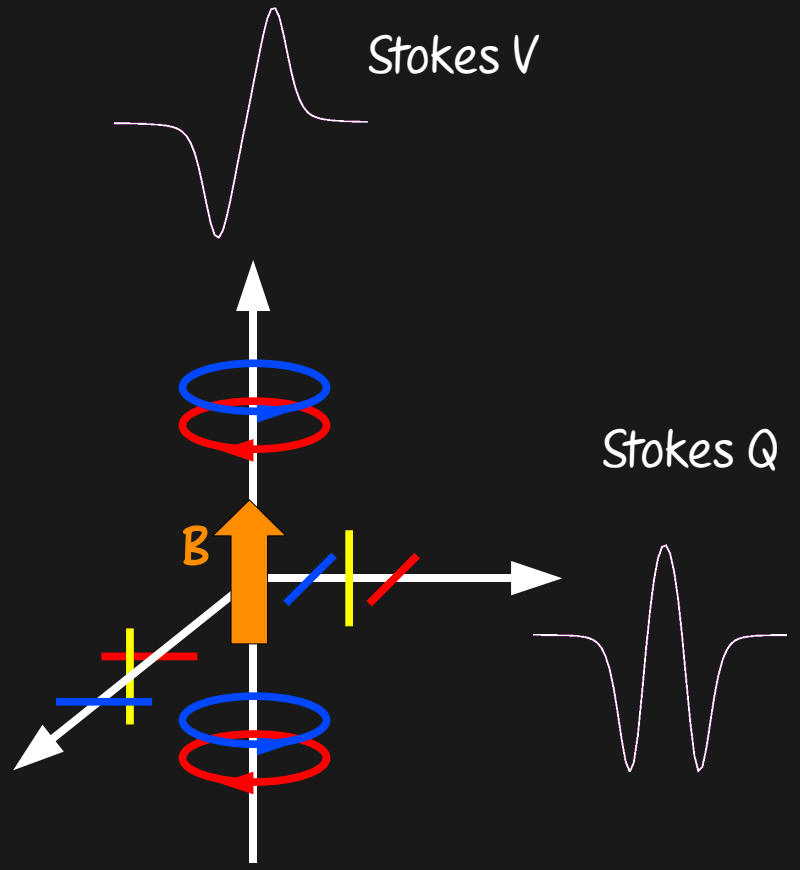
Which leads to an overpopulation of the triplet states



Zeeman, Hanle and scattering polarization

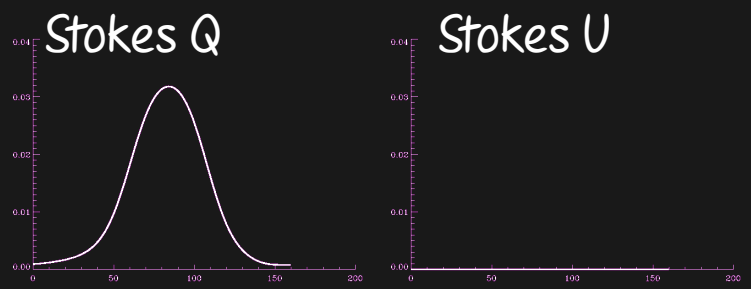


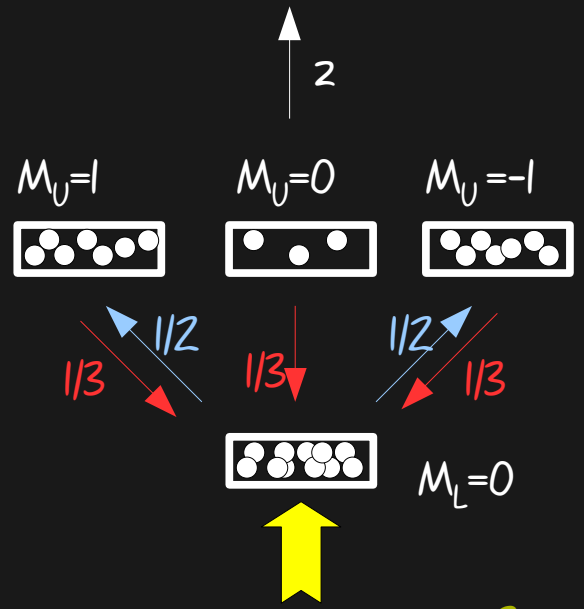




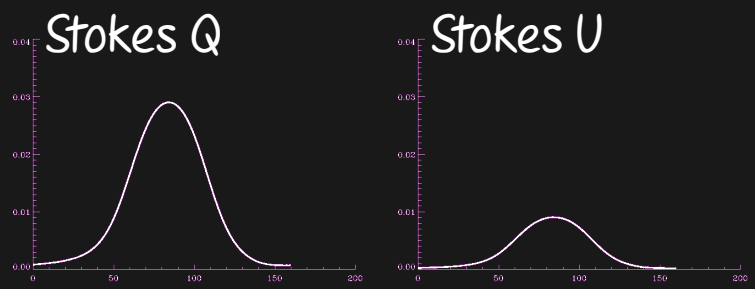
Zeeman, Hanle and scattering polarization

Scatt. Polarization (B = 0)





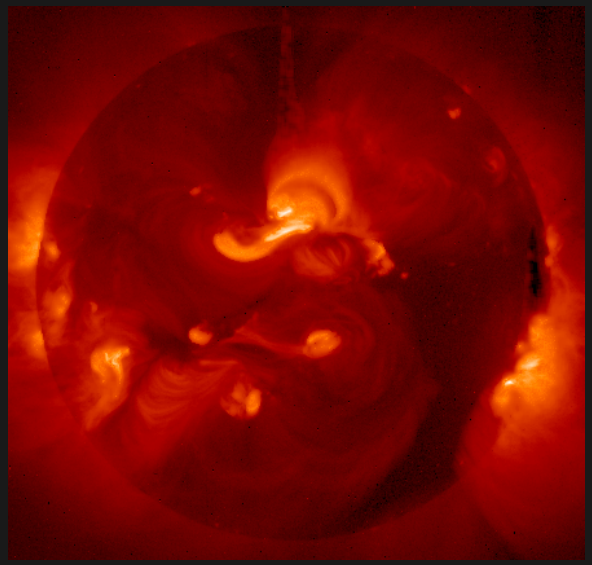
Hanle Effect (B ≠ 0)

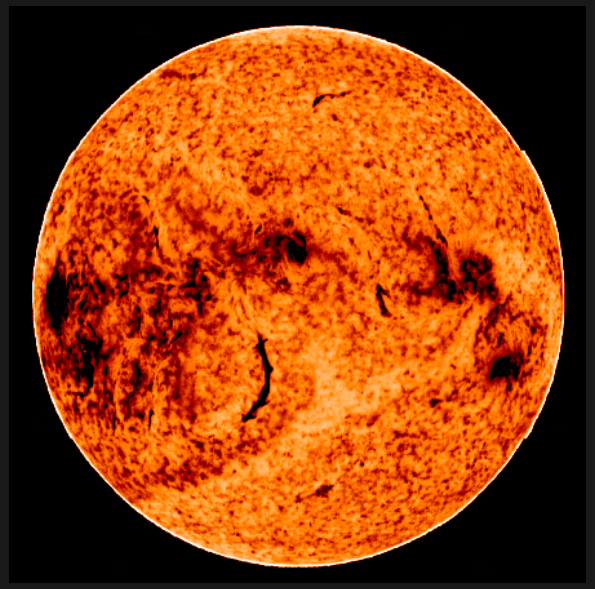


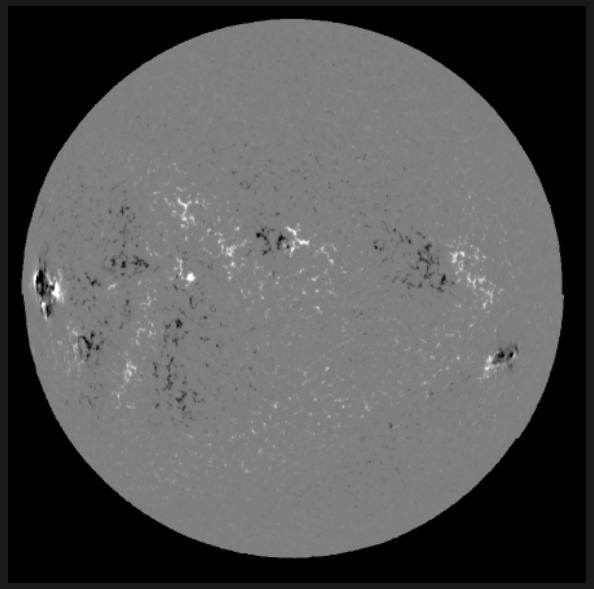
The presence of a magnetic field breaking the symmetry modifies the population imbalances and the quantum coherences between the magnetic sublevels, resulting in a net change and a rotation of the plane of polarization.

See review by Trujillo Bueno (2005)

First the bad things..







Spatial correlation with coronal activity. This means that it has barely any opacity in the quiet Sun. Warped layer of formation.

Proper forward modeling requires dealing with non-LTE problem: solving radiative transfer and statistical equilibrium equations consistently, including EUV coronal irradiation

The interpretation of scattering polarization (modification of sub-level population due to anisotropic illumination) and the Hanle effect is even more complicated

Now the good things...

Forms in a thin layer at the top of the chromosphere with NO influence from the photosphere

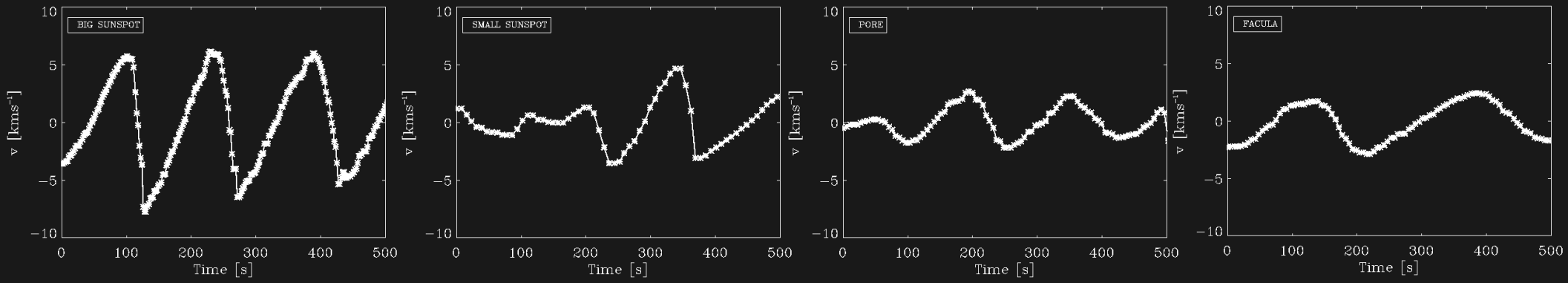
Magnetically sensitive – Zeeman splitting goes with λ^2

There is a photospheric line nearby (Si I 10827 Å) – simultaneous and cospatial measurements of the photosphere and chromosphere

For low-lying strcutrues it is easy to interpret signals with a simple Milne-Eddington inversor (in sunspots, plage, network..) -- Reliable magnetic field diagnostics!

It is sensitive to atomic level polarization and it's modification through the Hanle effect -- for high lying structures (prominences, filaments, spicules) that are anisotropically illuminated allows to measure magnetic fields as weak as mG to a few gauss. Difficult interpretation but inversion codes already available!!

Waves in magnetic structures

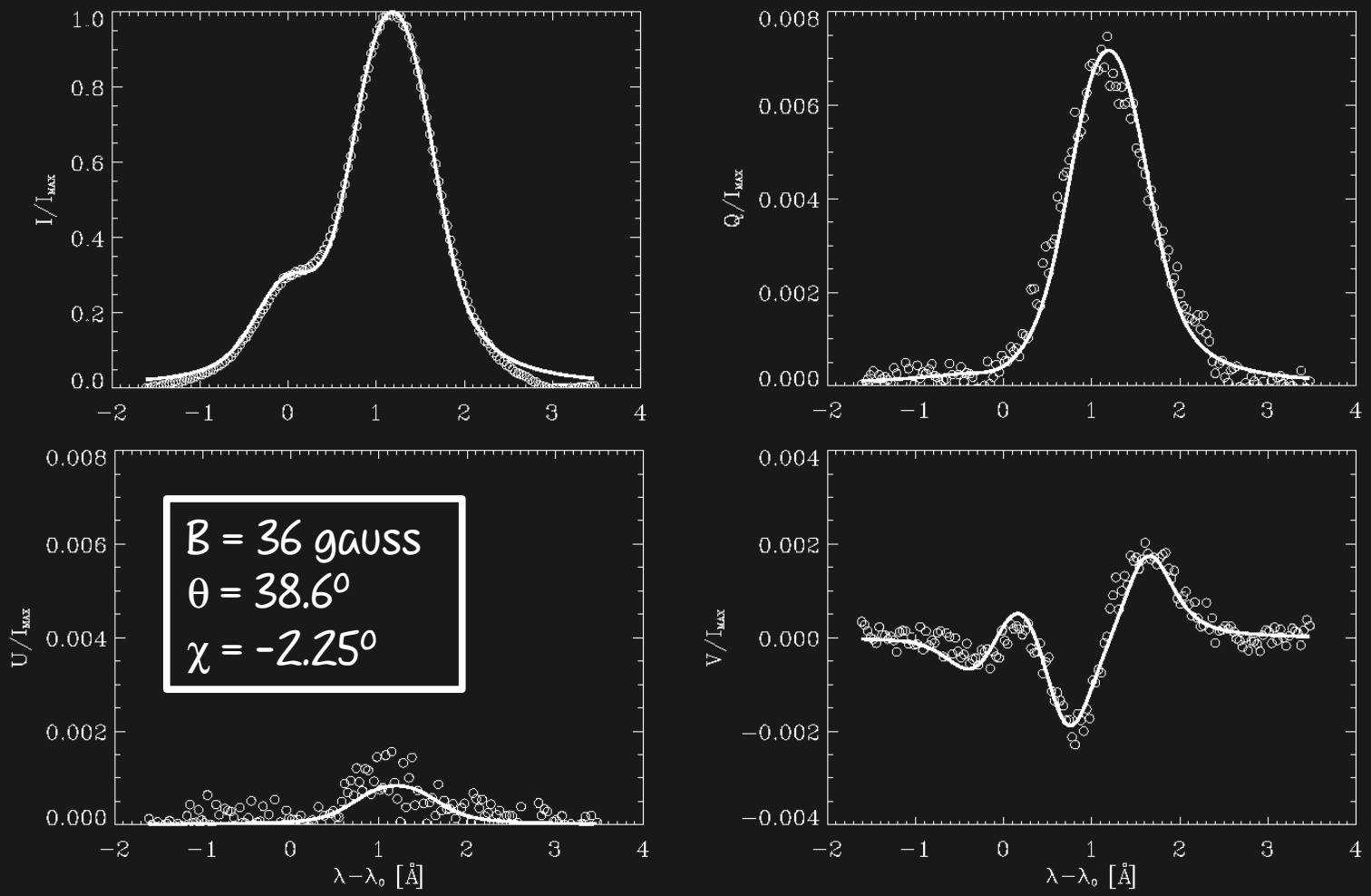


Big sunspot | Small sunspot | Pore | Plage

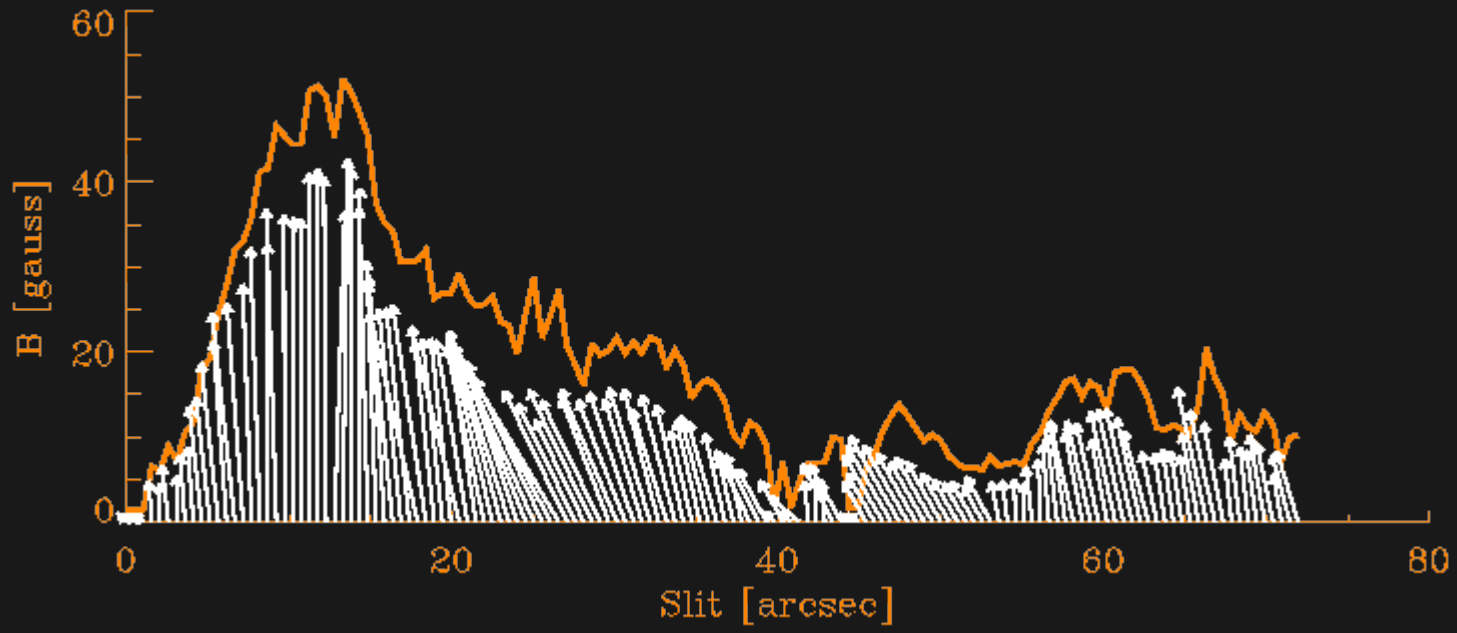
(Centeno et al. 2009)

* The He I 10830 multiplet is able to "see" the chromospheric dynamics of magnetized regions
* It can trace velocity oscillations and magnetic field configuration and evolution
* Waves provide clues about the thermodynamical and magnetic structure of the atmosphere

Spicules

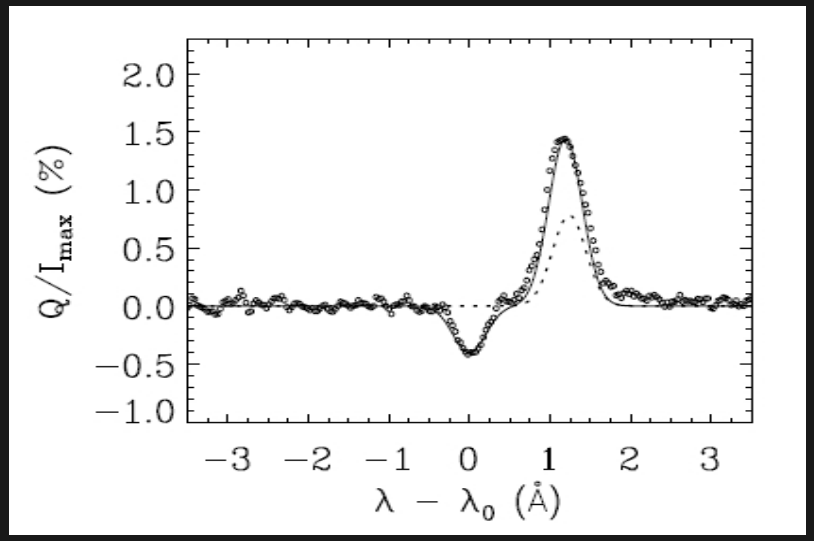


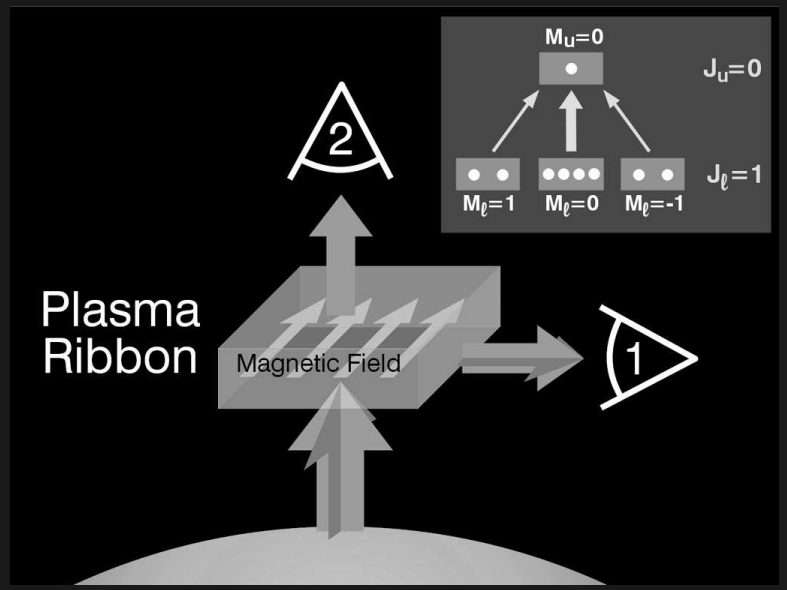
Spicules



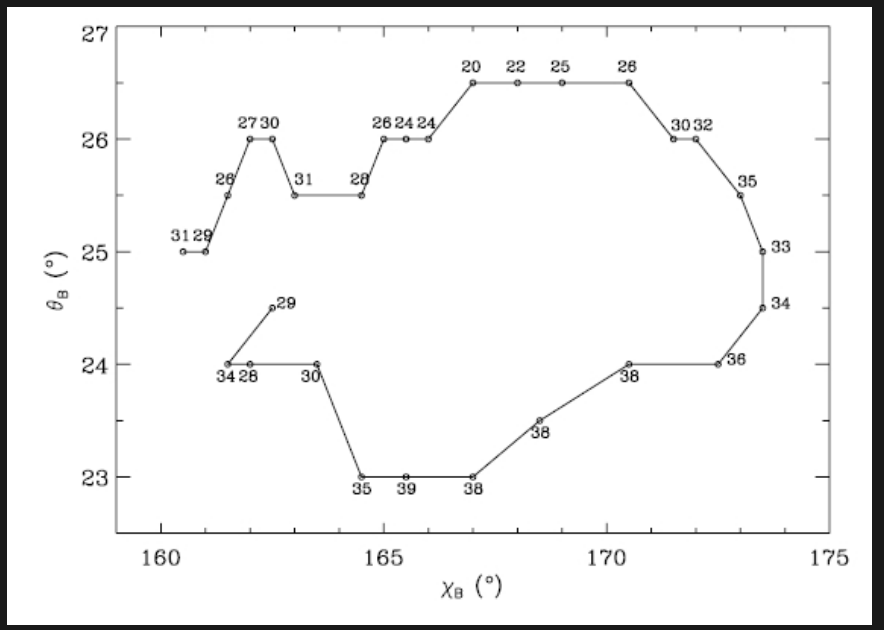
- The role of magnetic fields in the formation and dynamics of spicules?
- The properties of these fields
- How much do they change along the length of the spicule

Quiescent Prominences





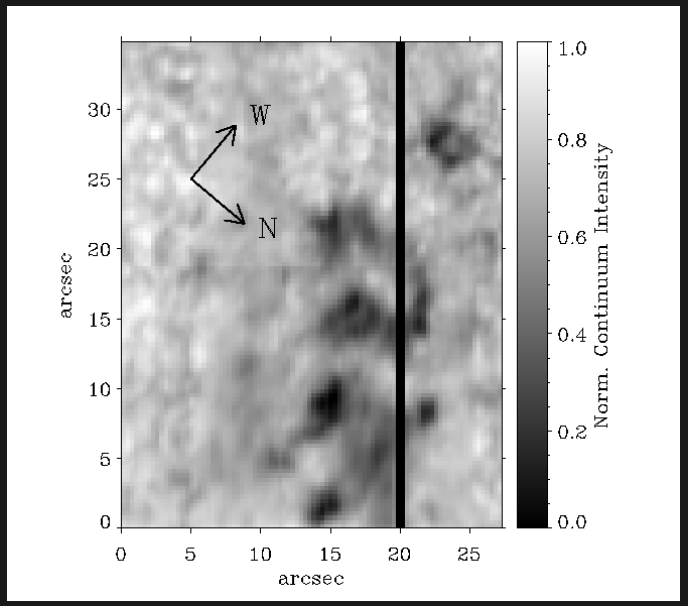
Trujillo Bueno et al. 2002



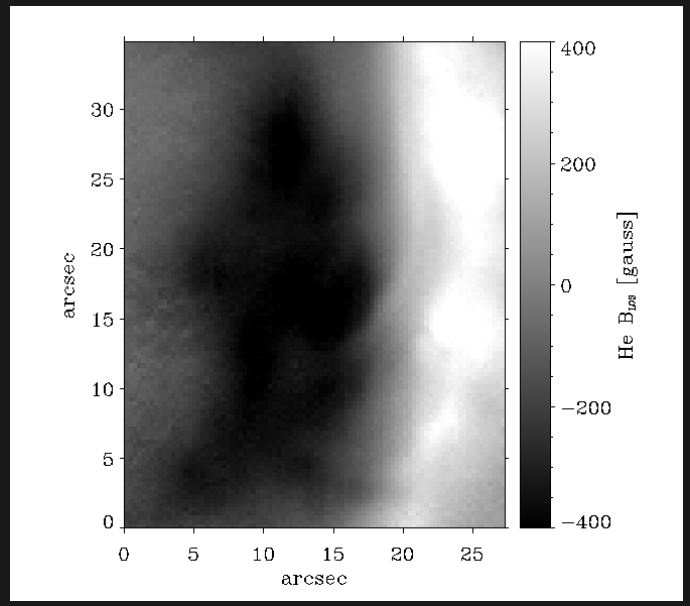
Merenda et al. 2006

AR Filaments (on disk)

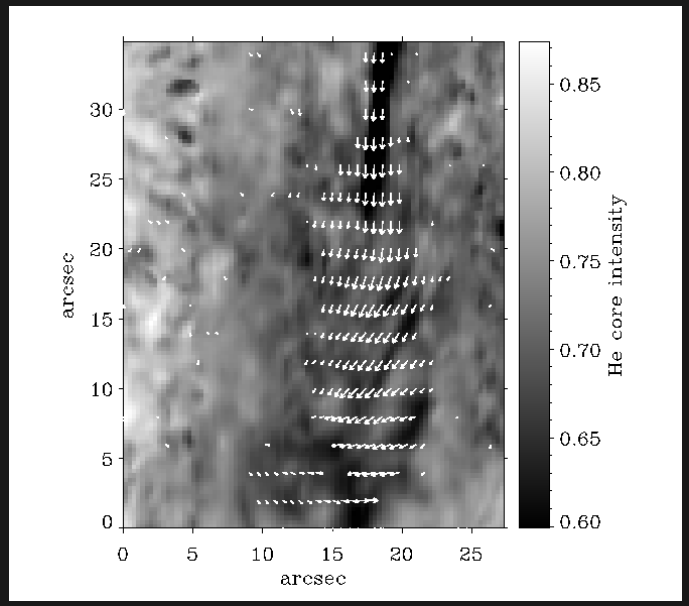
Continuum intensity



Chromospheric LOS magnetic field (He 10830)



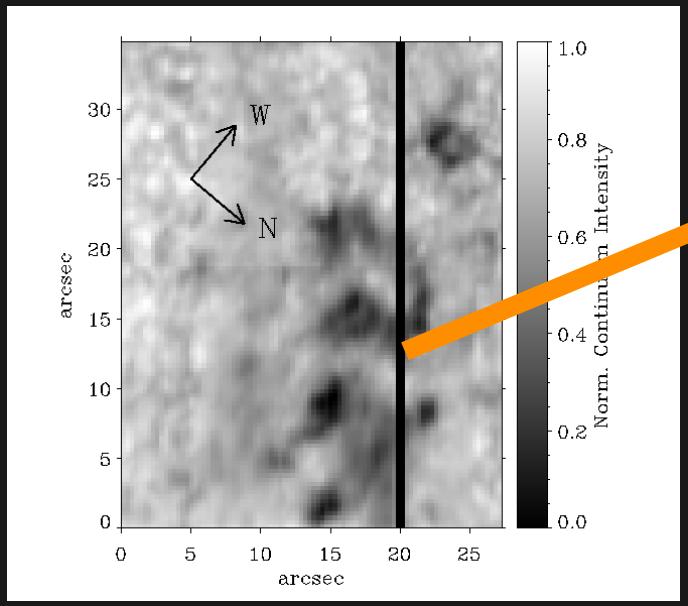
He core image and mag. field azimuth



(C. Kuckein et al. 2009)

AR Filaments (on disk)

Continuum intensity



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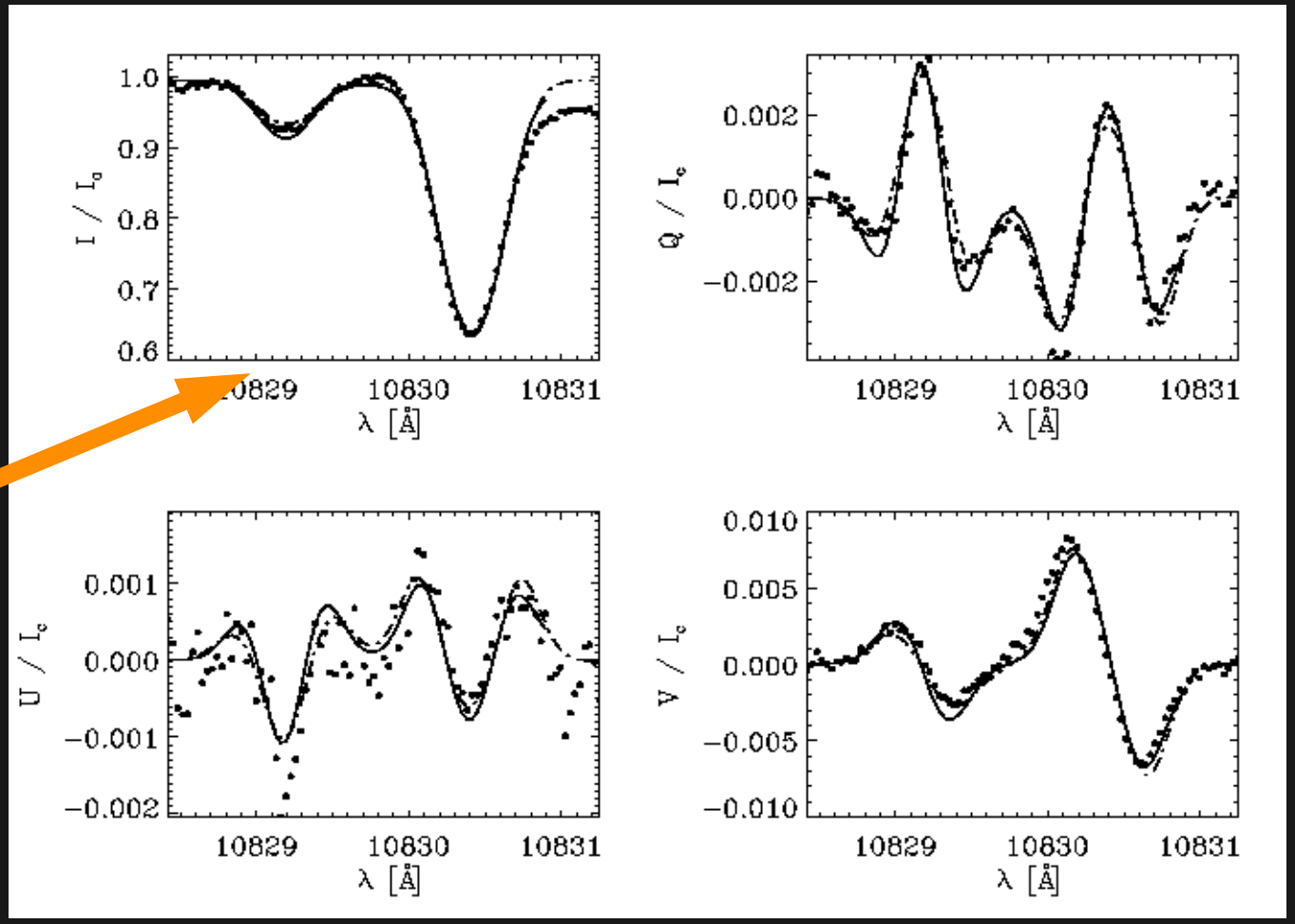

Inversions reveal magnetic fields as strong as 750 G in the Chromosphere and aligned with the rope-like structure

Into the future

The He I 10830 Å multiplet is a great tool for diagnosing chromospheric magnetic fields:

* It has no influence from the photosphere

* It works in a variety of different scenarios

* It's relatively easy to interpret its polarization signals with M-E in many cases

* When we can't do that, we can now resort to other inversion codes that account for scattering polarization and the Hanle effect

You know what would be REALLY AWESOME?