UV Polarimetry of the Second Solar Spectrum

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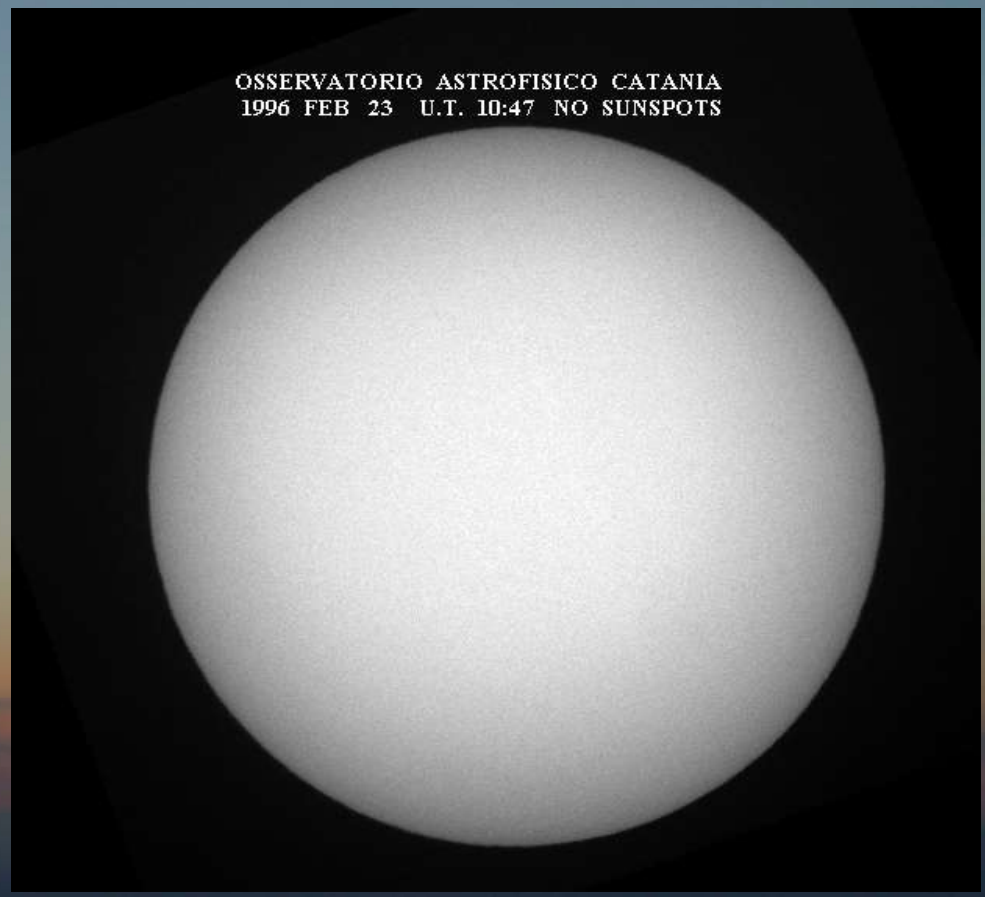
Scattering polarization at the Sun‘s limb

- Limb darkening:
  - Temperature stratification in photosphere
  - Anisotropic illumination
  - Scattering defines plane
  - POLARISATION



Scattering polarization

- Weak!
- Highly wavelength dependent:
  - Solar physics: λ-dependence of illumination anisotropy
  - Atomic physics: Polarizability of the line
  - Polarized radiative transfer effects

„spectrum of scattered radiation“

„The Second Solar Spectrum“

From scattering polarimetry to Hanle diagnostics

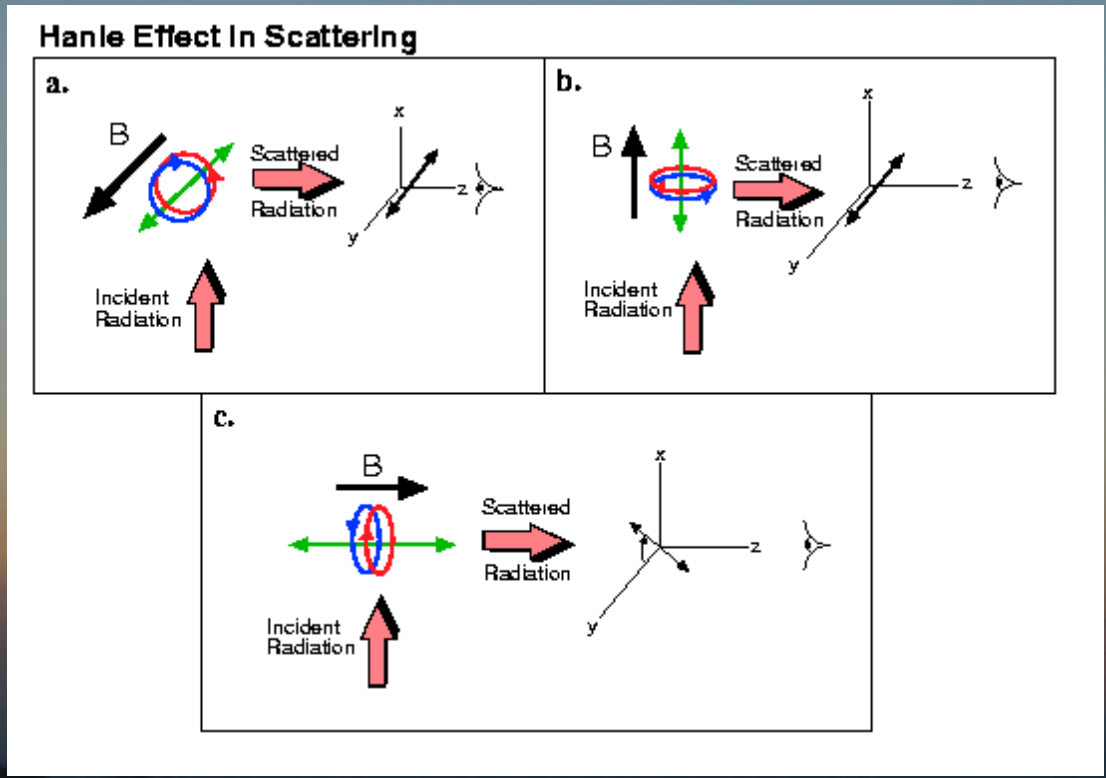
1.: Observing the „second solar spectrum“

2.: Understanding the „second solar spectrum“

3.: Using the „second solar spectrum“ as a tool for magnetic field diagnostics

Hanle diagnostics

- Hanle effect: Modification of scattering polarization in the presence of a magnetic field



Hanle effect

- rotation of the polarization plane
  - depends on field orientation
- depolarization
  - independent of field orientation
- for unresolved mixed polarity fields there will always be a depolarization effect!

When does the Hanle effect work?

- Needs scattering polarization
- best in upper photosphere and low chromosphere
- Works if Zeeman splitting is comparable to *natural* line width: 0.1 ... 100 G
- needs very high polarimetric sensitivity
- works best in near UV

the source of the polarization: the radiation anisotropy

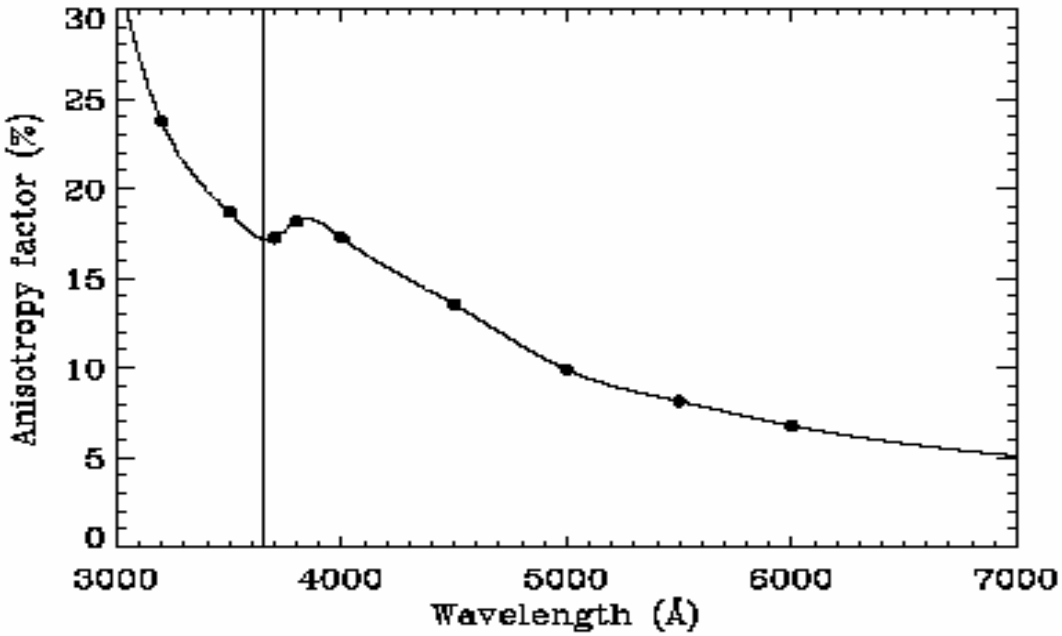
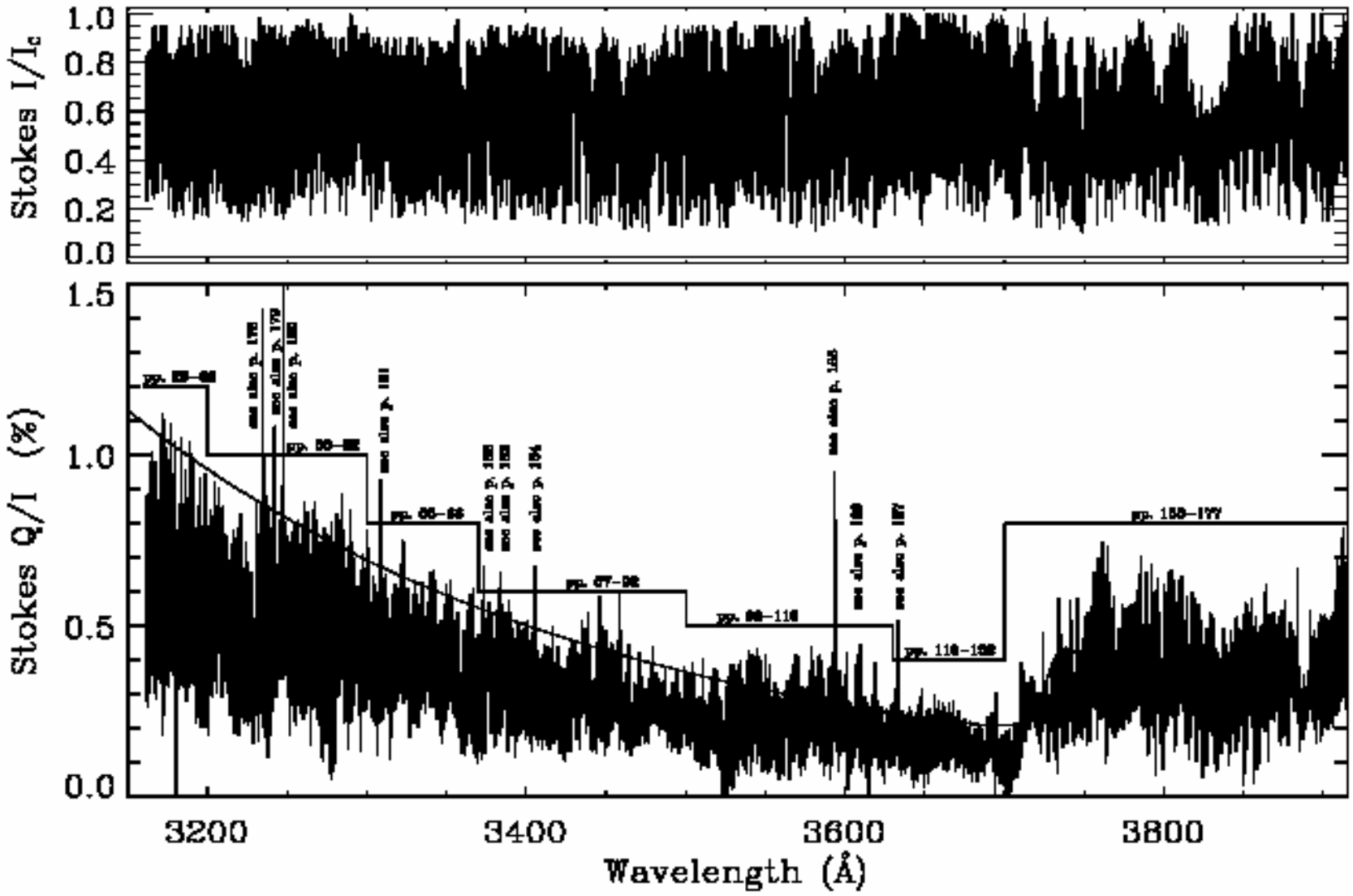


Fig. 1. Wavelength dependence of the anisotropy factor k_G for $\mu = 0.1$. Note that the effective Balmer jump occurs at substantially longer wavelengths than the actual series limit (marked by the vertical line).

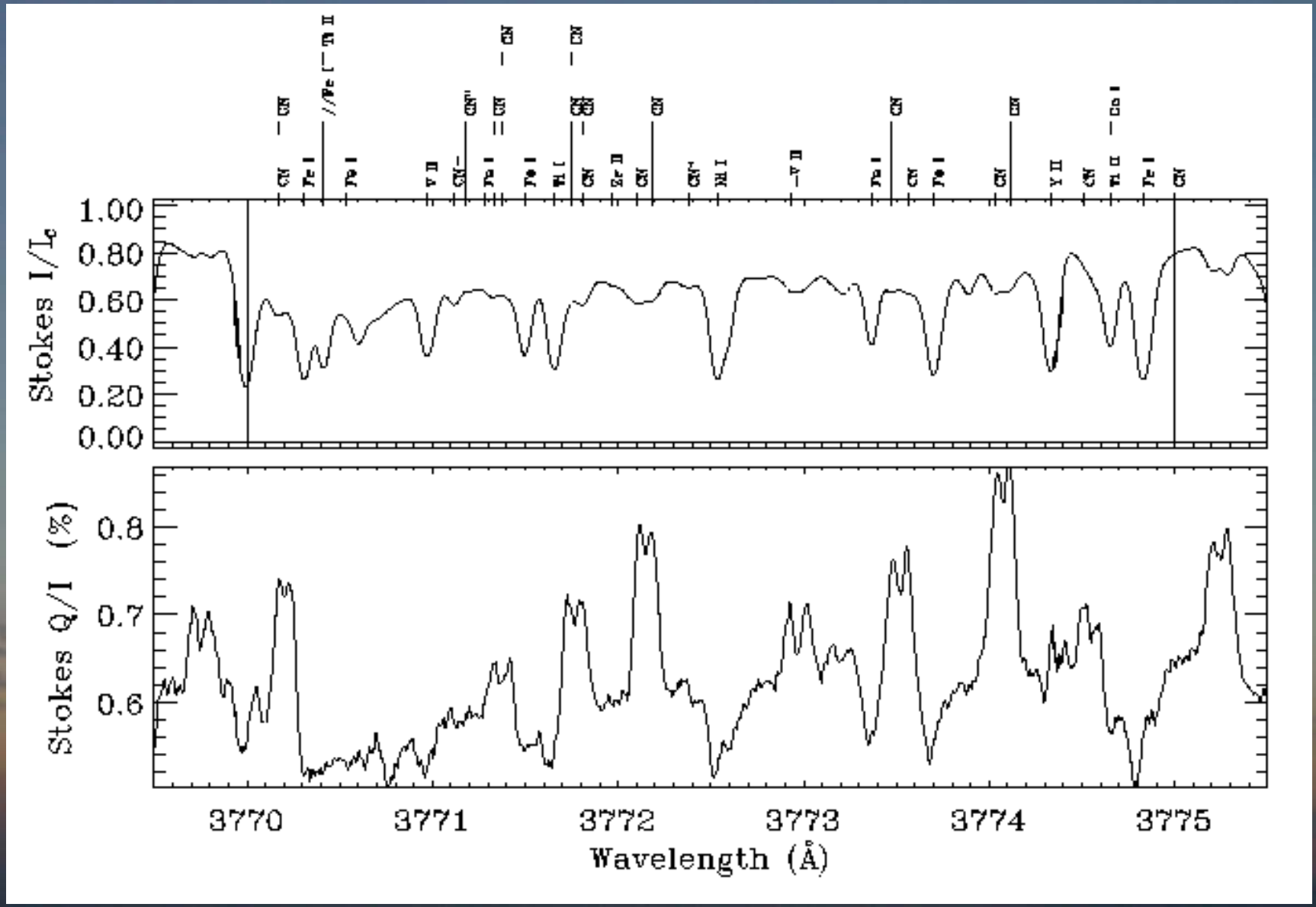
from Stenflo, J.O., 2005, A&A 429, 713

steep increase to shorter wavelengths

dominates the overall shape of the second solar spectrum



Gandorfer, "The Second Solar Spectrum", Vol. III



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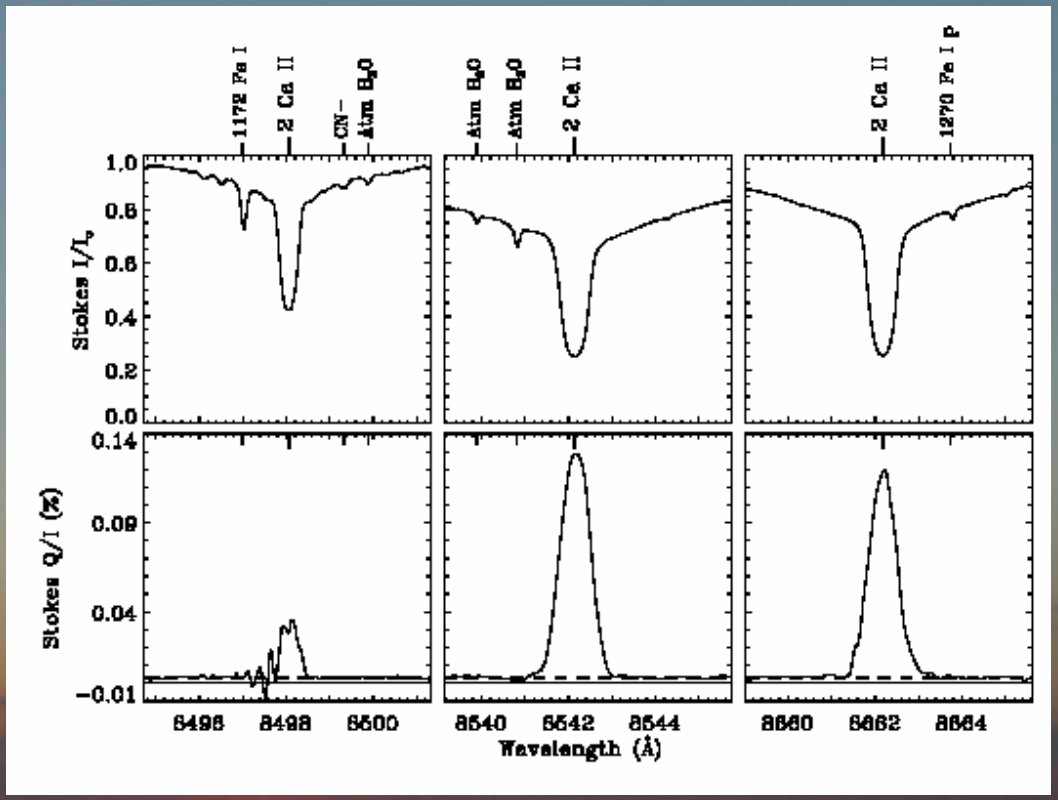
MPS contribution

- systematic exploration of the „second solar spectrum“
- atlas of the „second solar spectrum“ in three volumes published
- covers 316 nm – 700 nm
- most comprehensive reference data-set available

Lines that could be used for chromospheric Hanle diagnostics

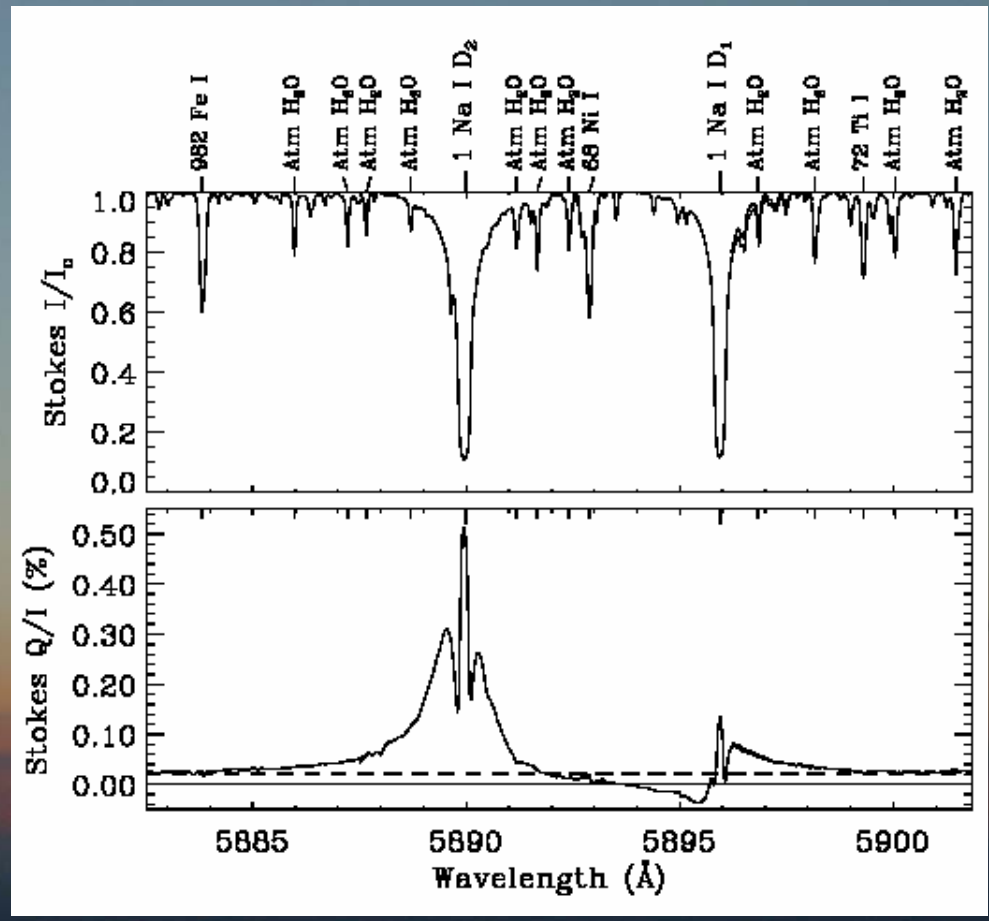
- Ca II IR triplett P<0.15%
  - can be used for differential Hanle effect, but only „without“ spatial resolution



Stenflo, J. O.; Keller, C. U.; Gandorfer, A., 2000: A&A 355, 789

Lines that could be used for chromospheric Hanle diagnostics

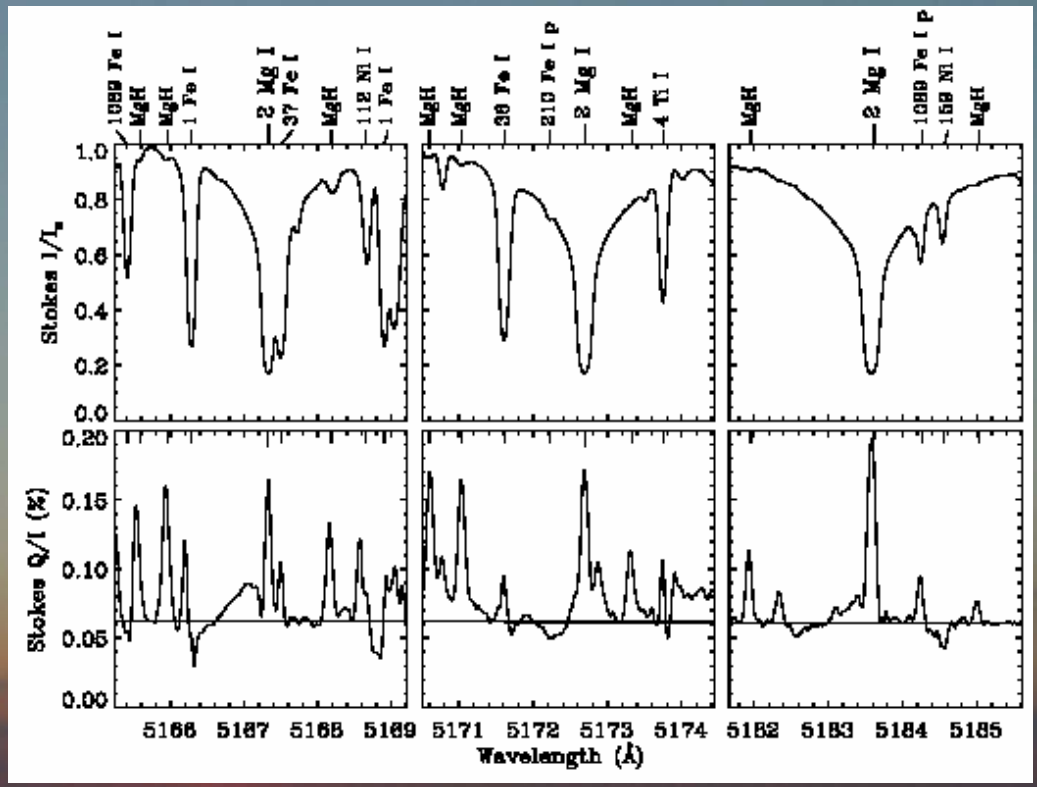
- Na I D_2 D_1 P<0.5%
  - has been used for mapping of the Hanle and Zeeman effects near the limb with moderate spatial resolution
  - quantitative magnetometry difficult, since line formation not fully clarified



Stenflo, J. O.; Keller, C. U.; Gandorfer, A., 2000: A&A 355, 789

Lines that could be used for chromospheric Hanle diagnostics

- H_α H_β P<0.1%
  - too weak, too complex
- Mg I b P<0.15%



Stenflo, J. O.; Keller, C. U.; Gandorfer, A., 2000: A&A 355, 789

Problems in Hanle work

- intrinsic weakness of scattering signals
  →very limited spatial resolution in most lines

Consequence: Observations of Hanle effect with moderate spatial resolution in strongest polarizing lines; most of these lines are found in the UV

Ca I 4227 Å P>2%

has been extensively used in the past:

without spatial resolution:

Faurobert-Scholl M., 1992 A&A 258, 521

Faurobert-Scholl M., 1994 A&A 285, 655

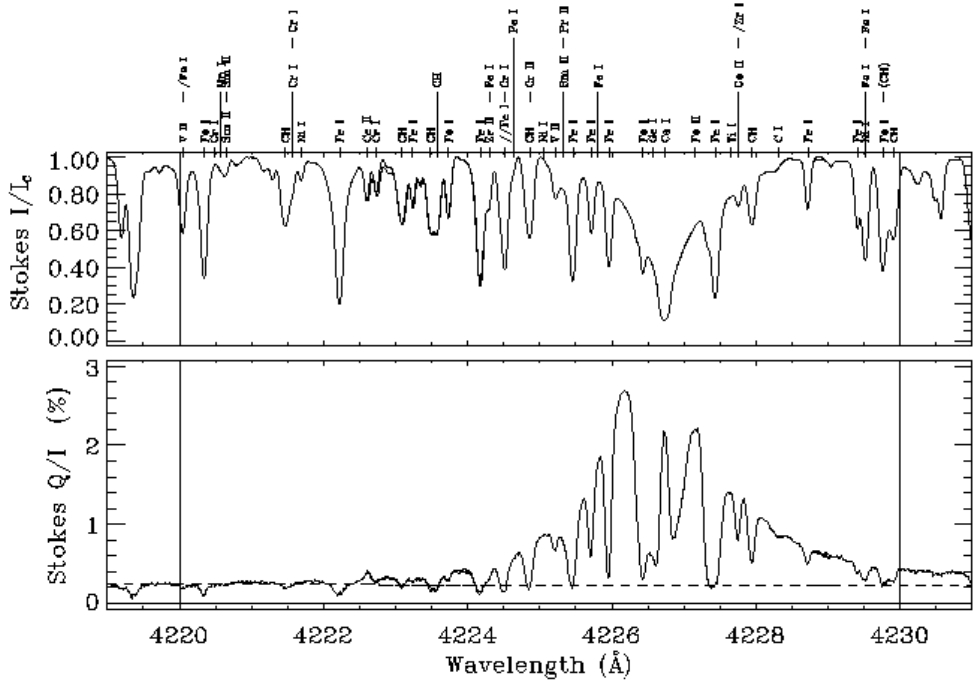
statistical analysis:

Bianda, M., Solanki, S. K., & Stenflo, J. O. 1998, A&A, 331, 760

Bianda, M., Stenflo, J. O., & Solanki, S. K. 1999, A&A, 350, 1060

with moderate spatial resolution:

Bianda, M.; Stenflo, J. O.; Gandorfer, A.; Gisler, D., 2003., ASPC 286, 61



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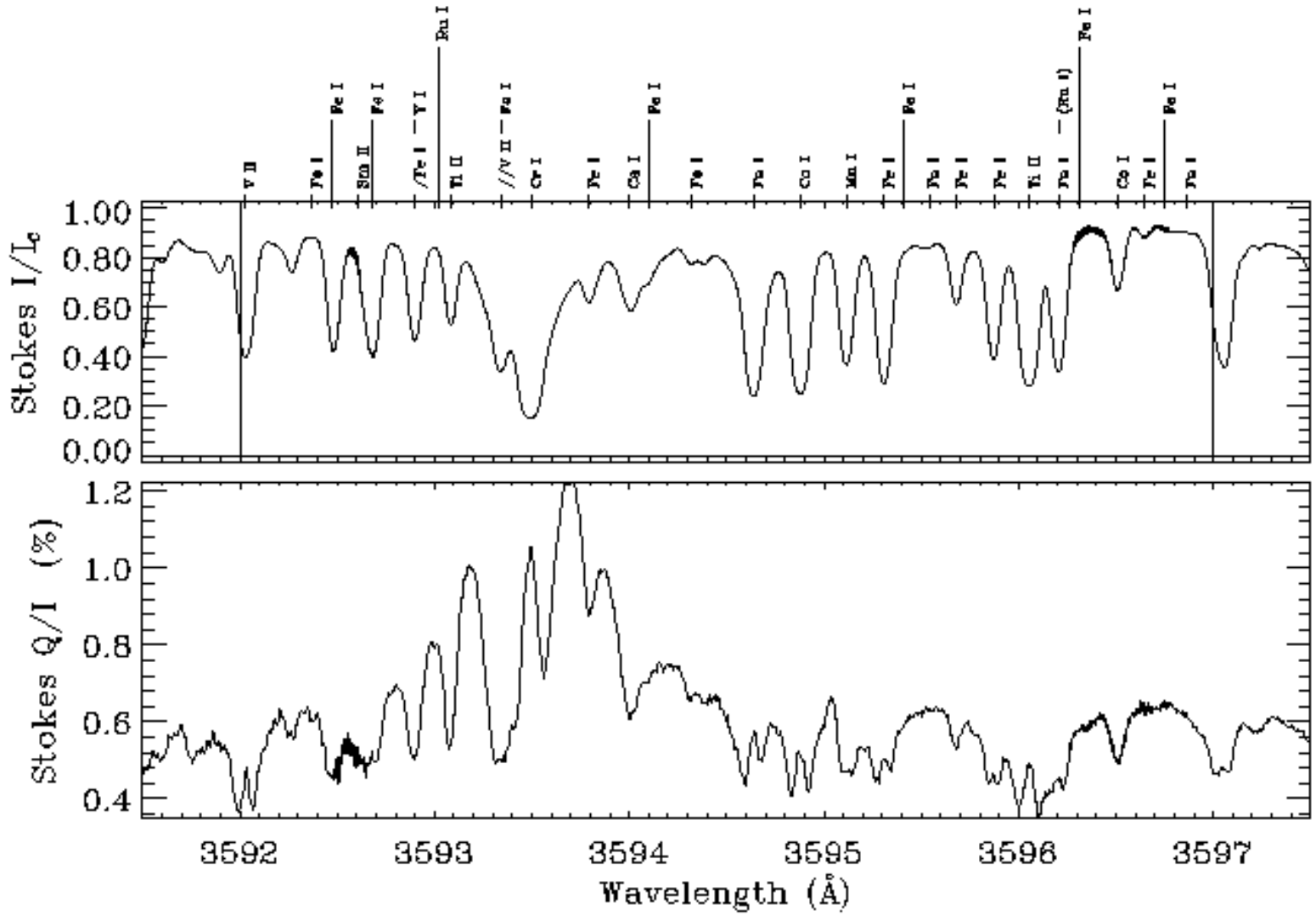
line formation is well understood

Holzreuter, R.; Fluri, D. M.; Stenflo, J. O., 2005, A&A 434, 713



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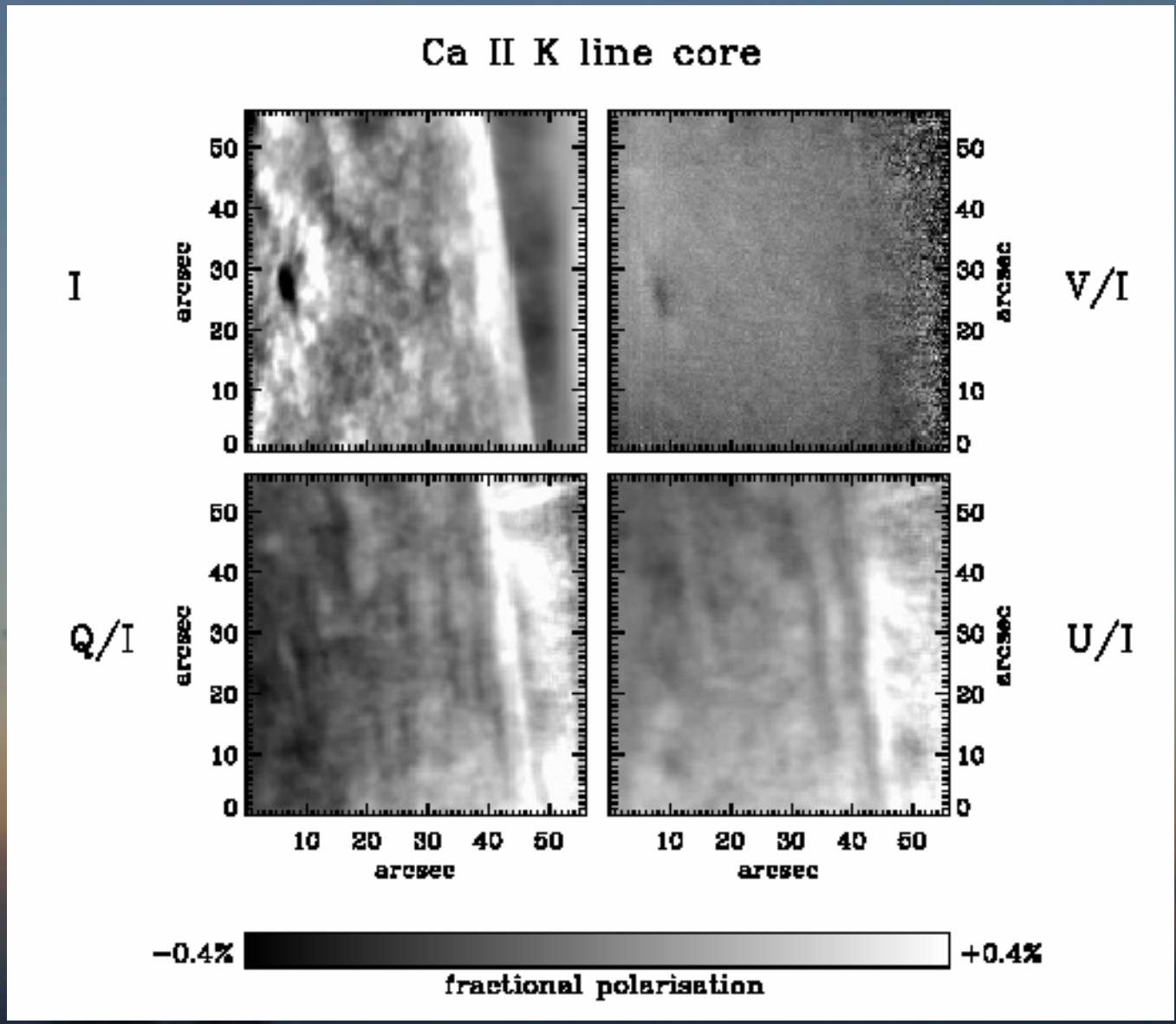
Ca II H&K

- very interesting for scattering polarimetry:
  - both show Zeeman effect Martinez Pillet et al., 1990, ApJ 361, 81
  - only K line exhibits scattering polarization
  - spectral signatures of scattering and Hanle effect are broad → can be imaged with narrow band filters


Ca II K line core
I
V/I
Q/I
U/I
arcsec
0
10
20
30
40
50
−0.4%
+0.4%
fractional polarisation

Conclusions

- spectral richness of the „second solar spectrum“ now fully explored
- we now have to identify most promising spectral features for future observing programs
- UV is very rich in strong chromospheric lines
- UV polarimetry might be the key to chromospheric magnetism