UV Polarimetry of the Second Solar Spectrum

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“Chromospheric and coronal magnetic fields”, MPS Katlenburg-Lindau. August 30, 2005
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: $\lambda$-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

steep increase to shorter wavelengths dominates the overall shape of the second solar spectrum

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).


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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 triplet**
  - P<0.15%
  - can be used for differential Hanle effect, but only "without" spatial resolution


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Lines that could be used for chromospheric Hanle diagnostics

- Na I D2 D1  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


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Lines that could be used for chromospheric Hanle diagnostics

- \(H\alpha\) \(H\beta\) \(P<0.1\%\)
  - too weak, too complex

- \(\text{Mg}\ I\ b\)
  \(P<0.15\%\)

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

statistical analysis:

with moderate spatial resolution:
Bianda, M.; Stenflo, J. O.; Gandorfer, A.; Gisler, D., 2003., ASPC 286, 61

line formation is well understood

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Ca II H&K

- very interesting for scattering polarimetry:
  - only K line exhibits scattering polarization
  - spectral signatures of scattering and Hanle effect are broad → can be imaged with narrow band filters
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