

Hanle rotation signatures in the Sr I 4607 Å line

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Context: "Magnatomy" of the Sun

Resolved vs. unresolved magnetic fields in the solar photosphere



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Context: Complementary diagnostic techniques for solar magnetic fields

Scattering polarization and the Hanle effect



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Scattering polarization and the Hanle effect

- Scattering processes result in a linearly polarized spectrum at the limb (continuum and spectral lines)
- continuum polarization requires accurate zero level
- ✤ faint polarization signals require high precision polarimetry
 - Resolved and unresolved magnetic fields modify scattering polarization via the Hanle effect (rotation and de-polarization)
- to interpret the linear polarization signals to use them for diagnostics, we need theoretical models



Intensity and linear polarization spectrum at the limb, Gandorfer (2002)

F. Zeuner



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• Signatures of Hanle rotation: non-zero U/I,

reduced Q/I, reduced $L=\sqrt{(Q/I^2+U/I^2)}$ (requests modeling for B=0)

in the core of scattering sensitive spectral lines







→ The main "enemies" of accuracy are **systematic errors**,

e.g. telescope induced offset polarization and polarization cross-talk, seeing induced cross-talk, post-focus instrument errors (fringes), etc.

 \rightarrow difficult to calibrate!

Usually, **assumptions** need to be made (on the shape of spectral lines or that the mean polarization at disk center is zero) to minimize systematic errors in data post-processing steps. However, post-processing can introduce artifacts, too.



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Enhancing the accuracy of polarimetry by coalescing slow and fast modulation

New measurement technique exploited at IRSOL: slow modulator in front of telescope



Sr I 4607 Å: strong scattering polarization amplitude

Sr I 4607 Å: upper photosphere, widely studied, up to 1% at the limb: ideal Hanle diagnostics line



Sr I 4607 Å: strong scattering polarization amplitude, but no Hanle rotation?

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IRSOL measurements for 73 min,

with exceptionally good seeing and with slow modulation technique (enhanced accuracy)





Sr I 4607 Å: Hanle rotation detected?

IRSOL measurements





Sr I 4607 Å: Hanle rotation detected?

Exclude systematic errors



 \rightarrow Q/I limb amplitude consistent with atlas

→ spectral shape of U/I single peaked

→ no signature of Zeeman in Fe I Q/I, U/I (no cross-talk from V/I, no transversal B fields)

 \rightarrow Q/I \rightarrow U/I cross-talk can not produce alternating signs

Zeuner et al. (2022b)

Sr I 4607 Å: Hanle rotation detected!

U/I with V/I amplitudes correlation



- Hanle rotation detected on long time scales in Sr I 4607 Å, several μ positions
- Probably the main reason why we lack regular detection in the past is the lack of zero level accuracy → solution at IRSOL and GREGOR using additional slow modulation
- Future: model Q/I CLV for B₀=0, B⊤≈130 G for B₀ diagnosis
- Future: DKIST (is the data calibrated well enough?, short time scales?)

