Abstract
We investigate the polarization of spectral lines in the penumbra of sunspots by integrating the radiative transfer equation of polarized light for a three-dimensional axially symmetric model atmosphere of a sunspot. The Evershed flow is confined to horizontal magnetic flux tubes, which are embedded in an inclined magnetic field. We compute the net circular polarization (NCP), $N = V(\lambda) / I(\lambda)$, of the two photospheric spectral lines Fe I 630.25 nm and Fe I 1564.8 nm. Analyzing spectra at a fixed distance from the spot center, we find that the azimuthal variation, $N(\psi)$, is an antisymmetric function of $\psi$ with respect to the line connecting disk center and spot center for Fe I 1564.8 nm, while the variation is predominantly symmetric for Fe I 630.25 nm. We show that the antisymmetric variation is caused by anomalous dispersion.

A Sunspot Model

- Tripartite magnetostatic sunspot model (Jahn & Schmidt 1994)
- Moving flux tube model (Schlichenmaier et al. 1998): heat transport: mixing length theory, heat exchange at the magneto-pause, concept of interchange convection
- Three-dimensional representation & radiative transfer module SPOTMACHINE (Müller et al. 2002)

Vertical cut through the penumbra:
- Background: axisymmetric vector field
- Field-aligned flow inside flux tube

Asymmetric Stokes-V Profiles

Radiative Transfer Equation for Polarized Light

Breaking the Symmetry: Azimuthal Jump

Synthetic NCP-Maps & Comparison With Observations

Conclusions
- Observed NCP distribution can be reproduced by uncombed magnetic fields
- Symmetry breaking by anomalous dispersion is essential to understand observations
- Multi-line analysis facilitates discrimination between different atmospheric configurations
- Synthetic Stokes maps can be used to retrieve physical quantities of the penumbra (Stokes inversion)

References