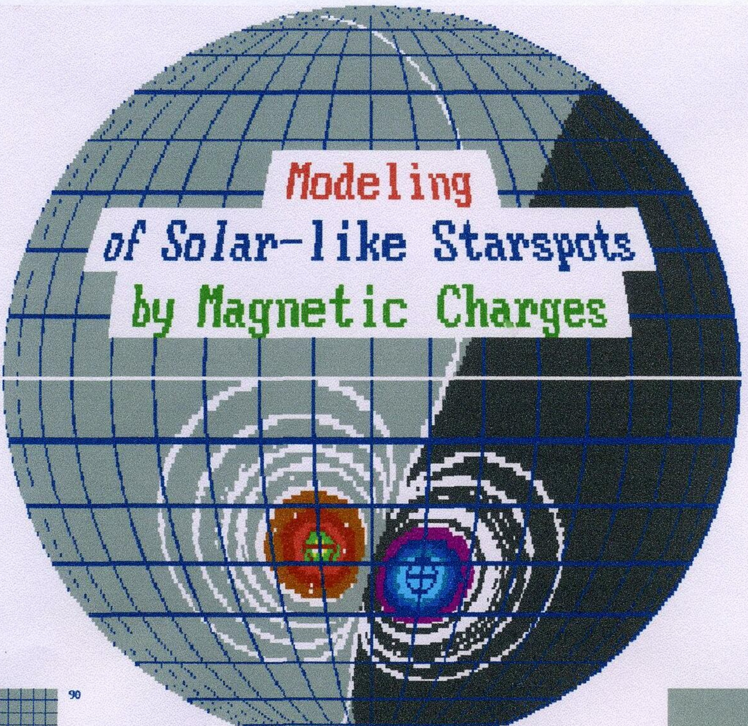


Modeling of Solar-like Starspots by Magnetic Charges

Gerth, E. and Glagolevskij, Yu. V.

The sun is the only star, which exhibits by observation from the earth a detailed topographic structure. The origin of the conspicuous spots has been attributed to magneto-hydrodynamic processes in the plasma, which are described well by the dynamo theory.

Supposing, the generation of sun-spots by the action of a dynamo is bound to the spectral class, then also in other G-stars solar-like starspots accompanied by magnetic phenomena should be revealed. Since we receive from all other stars only the integral radiation, we have to disentangle the information by an inversion procedure. Modeling methods, however, can help to asses the effect of such spots onto the integral magnetic field.

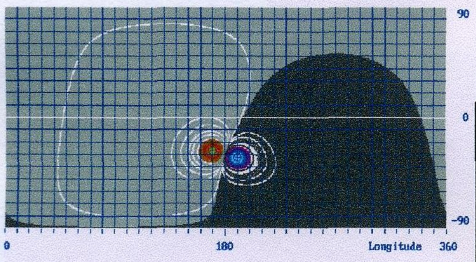
For the investigation of solar-like spots in stars we propose here a modeling method of the "*Magnetic Charge Distribution*" (MCD), which has been applied up to now only to stars with global extension of strong magnetic fields.

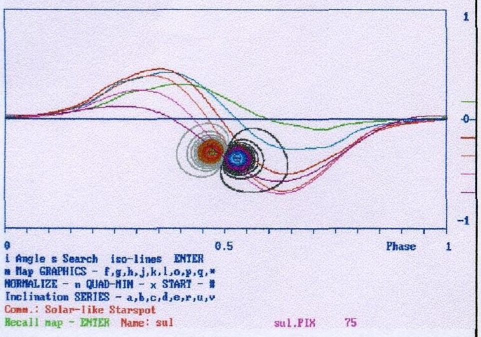
A solar-like spot can be constructed as an arrangement of magnetic dipoles under the surface of the star/sun. After this model the typical phase curves produced by such a magnetic spot and the line profiles according to all 4 Stokes-parameters in polarized integral light are calculated using a special computer program.

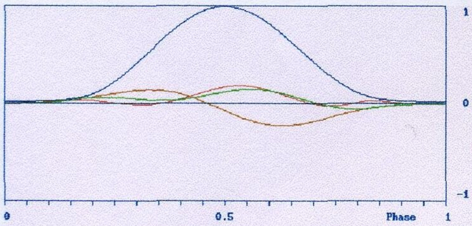
A general description of the program is given in (1) and the theoretical foundation for the algorithms used done in (2).

The philosophy of the MCD-Method relates to a definite theorem of the potential theory, according to which any field configuration can be produced by superposition of the fields of numerous point-like sources. The closed magnetic lines of force converge to *virtual sources* with "magnetic charges".

(1) E. Gerth, Yu.V. Glagolevskij, G. Scholz. 1998, Contrib. Astron. Obs. Skalnaté Pleso, Vol. **27**, 455
(2) E. Gerth, Yu.V. Glagolevskij. 2001, Astron. Soc.Pac., Conference Ser., Vol. **248**, 73





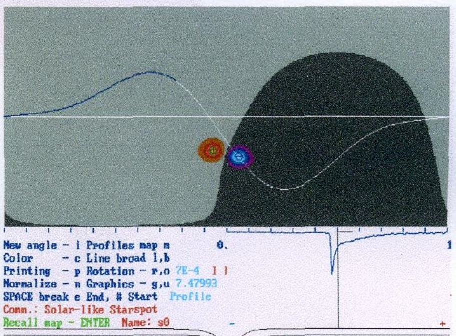


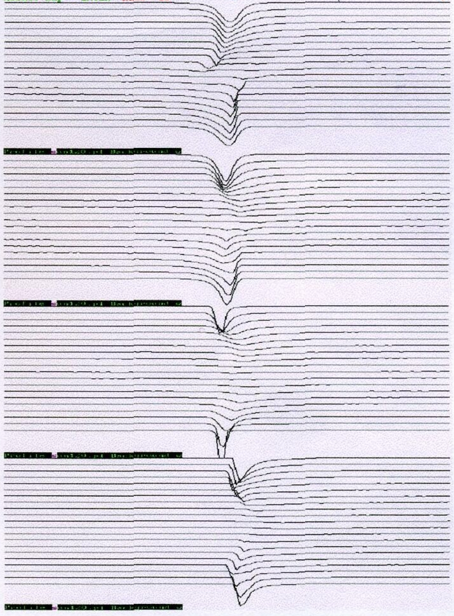
1. Mercator-map of the magnetic surface field of a spot.
   Sources: $\varphi_1=170°$ $\delta_1=-27.5°$ $r_1=0.88$ $Q_1=+1$
   $\varphi_2=190°$ $\delta_2=-32.5°$ $r_2=0.92$ $Q_2=-1$

2. Spot feature and corresponding phase curves of the integral magnetic field (longitudinal – Stokes V) for the inclination angles $i=80°$ to 150° by step 10° (marked by colors), used for fitting. Bottom: Computer-menu.

3. Phase curves of the integral magnetic field strength measured by the Zeeman-effect in polarized light.
   Brown - circularly polarized light - Stokes V
   Red - long-linearly polarized - Stokes Q
   Green - cross-linearly polarized - Stokes U
   Blue - absolute surface field - Stokes I

   All polarization types are vignetted by limb darkening separately. The ordinate of Stokes I is reduced by 1/3.





4. Phase curve of the integral magnetic field (Stokes V) corresponding to the Mercator-map with spot feature. The line profile at the phase 0.4 (black to white) is extremely asymmetric with the peek at the negative side and the gravity center at the positive one. In the course of the phase the peek and the gravity center oscillate in antiphase. Bottom left: Computer-menu.

5. Course of the line profile over the period by 20 steps. On the opposite side of the spot a symmetric profile is developed, which becomes asymmetric approaching to the spot in the different modes of polarized light with characteristic phase behavior (jump in V).
   a) circularly polarized light - Stokes V
   b) long-linearly polarized light - Stokes U
   c) cross-linearly polarized light - Stokes Q
   d) natural unpolarized light - Stokes I

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