EVIDENCE FOR AN X-TYPE NEUTRAL SHEET PRODUCING CHROMOSPHERIC ACTIVITY

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Abstract. Force-free magnetic field extrapolation for region McMath 12417 on 4 July 1973 corroborates a suggestion by Roy and Michalitsanos (1974): A large moving magnetic feature presses together opposite fluxes to form an X-type neutral sheet; the supposed geometry of the field as derived from chromospheric activity (subflares, ejections) is confirmed by the calculated lines of force.

McMath region 12417 from 1 to 10 July 1973 has been studied by a number of authors because high quality observations (filtergrams in Hα and Ca II K, videomagnetograms) were obtained at the Big Bear (Roy and Michalitsanos, 1974 – hereafter referred to as RM; Zirin, 1974a, b; Tang, 1978) and CSIRO Solar Observatories (Culgoora: Bray, 1974; Loughhead, 1974; Maltby, 1975); RM also used a magnetogram obtained at the Sacramento Peak Observatory on 4 July, 13 : 31 UT. Interconnecting loops within a larger complex of activity including McMath 12417 have been derived from soft X-ray observations on Skylab (Howard and Švestka, 1977; Švestka *et al.*, 1977), and global potential magnetic fields were calculated from Kitt Peak National Observatory magnetograms (Altschuler *et al.*, 1977).

At the Einstein tower telescope in Potsdam photoelectric magnetograms (line-of-sight component $B_{\|}$ in the photosphere) were obtained on July 4, 08 : 30 (Figure 1) and 13:00 UT, in the line of Fe I 5253.5, with a resolution of 7''.5:6''.0 in the EW:NS directions, respectively. Details of our equipment and treatment of the observational data are described by Bachmann *et al.* (1975). The magnetrogram of 08:30 UT was used for a force-free magnetic field extrapolation to higher levels of the solar atmosphere assuming $\nabla \times \mathbf{B} = \alpha \mathbf{B}$ with $\alpha =$ constant. The method (Seehafer, 1978) does not require the net magnetic flux through the magnetogram area to be zero, only the vertical field component is assumed to vanish at the lateral boundary planes of the considered volume. The procedure has already been applied to region McMath 11976 of August 1972 (Seehafer and Staude, 1979). Magnetic lines of force have been calculated, starting from a mesh of foot points every 10'':10''. A comparison with Hα fibrils suggested the best value of α to be $-0.5\alpha_{\max}$, where $\alpha^2_{\max} = \pi^2(L_x^{-2} + L_y^{-2})$, L_x and L_y being the extents of the magnetogram in both directions. Figures 2 and 3 show the calculated lines of force in overview (2) and perspective (3),

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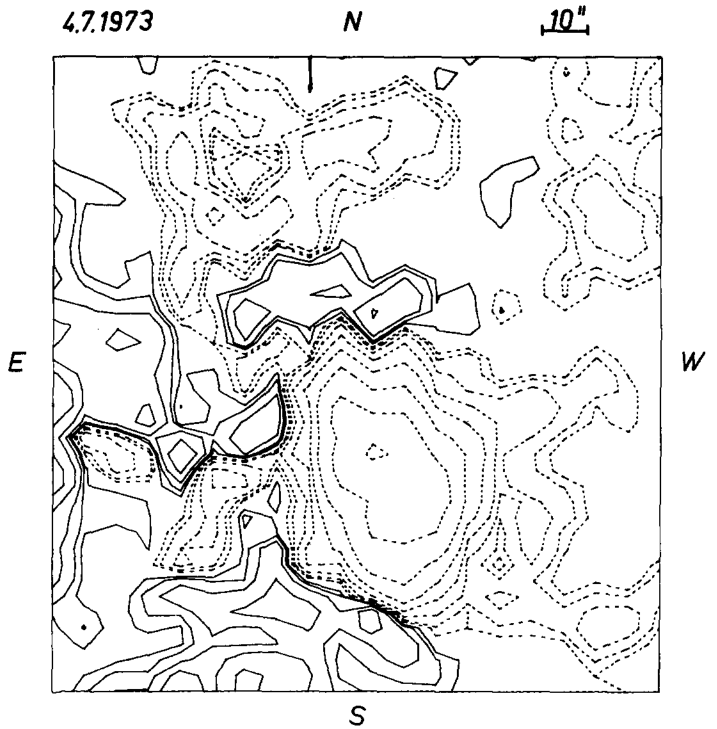
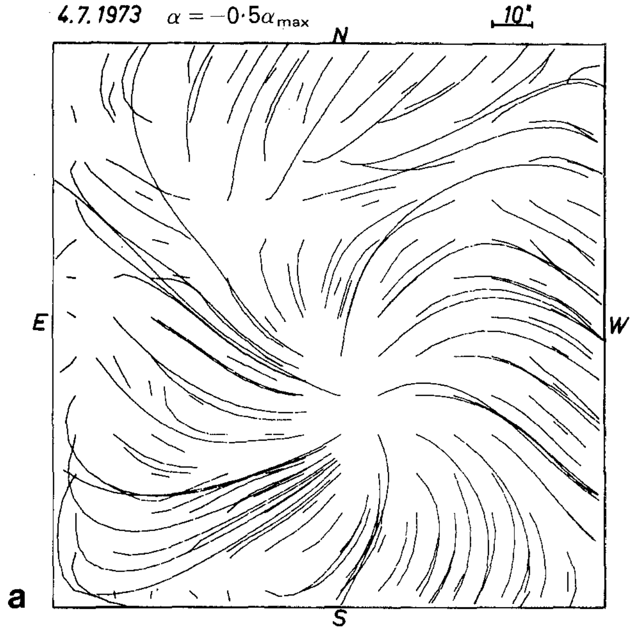


Fig. 1. Photoelectric magnetogram ($B_\parallel$) obtained at the Solar Observatory Einsteinturm in Potsdam on 4 July 1973, 08:30 UT. Contour levels are 20, 40, 80, 160, 320, 640, 1280, and 2560 G. Solid contours are (+) fields, dashed (−).

the latter giving some information on the height extent of the lines of force. Figure 2b for the potential field $\alpha = 0$ is shown for comparison.

The considered region is characterized by a large sunspot of $p(-)$ polarity (towards S from the centre in Figure 1). In the north of the spot a feature of $f(+)$ polarity, elongated in EW direction and embedded in an area of opposite $(-)$ polarity, moves away from the spot. Our magnetogram does not include the large plage of f polarity in E, but the strongly sheared line of $B_\parallel = 0$ is clearly to be seen. This shear in connection with a few high-reaching lines of force (loops) was probably responsible for the umbral flare observed on 5 July (Zirin, 1974b; Tang, 1978), but we are more interested in the moving magnetic feature (MMF) on 4 July: RM observed chromospheric brightenings (subflares) at the northern boundary of the MMF close to the $B_\parallel = 0$ line; sometimes occuring simultaneous brightenings at the northern boundary of the spot suggest a connection by lines of force. Ejections starting from the $B_\parallel = 0$ line in the north of the MMF mainly moved to the north away from the spot, only sometimes RM observed smaller ejections towards the south, in both cases probably following magnetic lines of force. RM suggested an X-type neutral line at the northern boundary of the MMF, formed by the compression of oppositely directed lines of force. This conception is completely corroborated by our



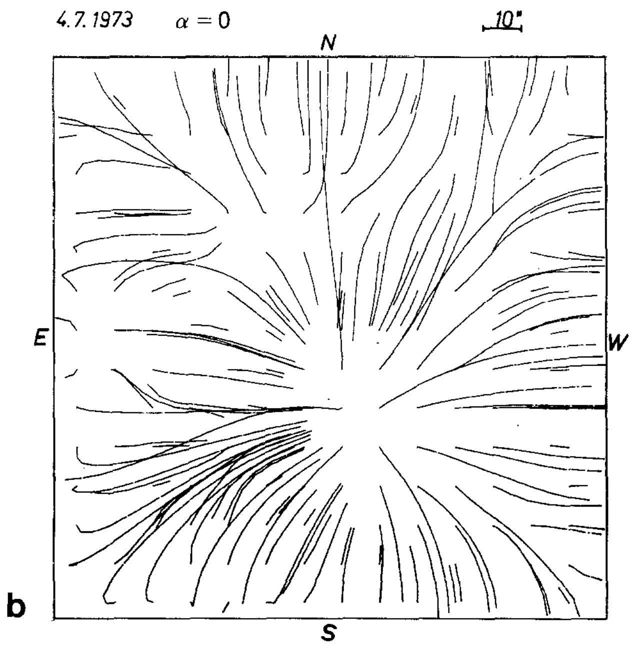


Fig. 2. Overview of the calculated lines of force above the region of Figure 1 for a force-free field (a) and a potential field (b).

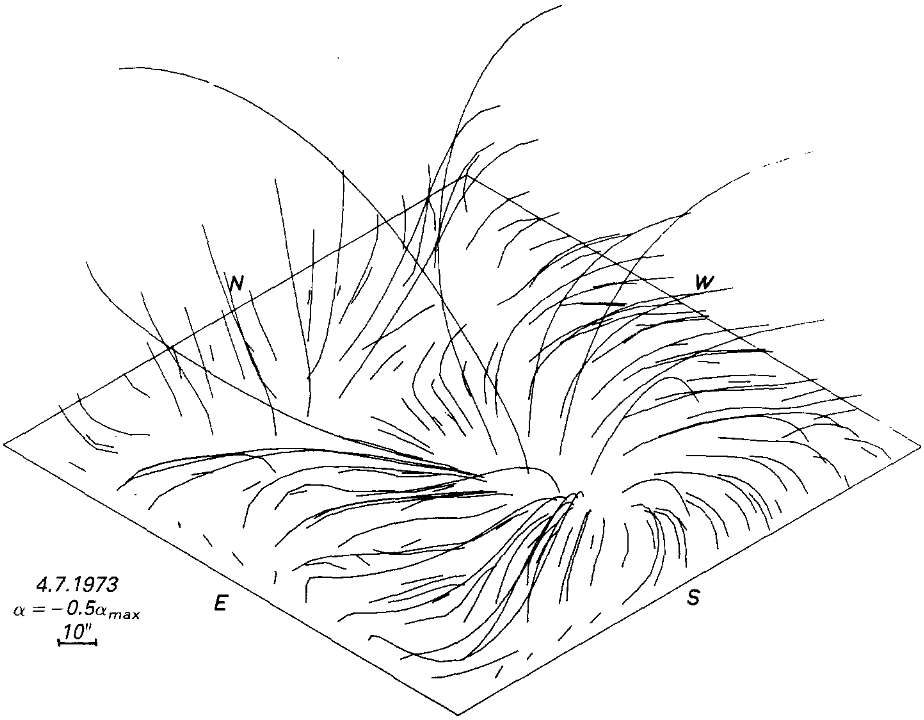


Fig. 3. Perspective (isometric projection) view of the same calculated lines of force as in Figure 2a.

magnetic field extrapolation: Magnetic lines of force mainly curve in S–N direction from the spot to the MMF and from the (−) polarity northerly of the MMF further to the N.

In the chromosphere and corona above the $B_{\|} = 0$ line where the opposite lines of force are pressed together we found very low absolute values of the magnetic field vector, amounting to some percent of those of the strong field regions. This is not the case above the other $B_{\|} = 0$ lines, e.g. between spot and MMF, where strong horizontal magnetic fields resulted from the calculations. The picture of the neutral sheet caused by horizontal connection of opposite magnetic flux looks like an example in an illustrated textbook, but the chromospheric activity was only moderate. Similar activity was observed in another example of vertical connection caused by a small bipolar flux region emerging with opposite direction of the magnetic field within an existing active region (Bachmann, 1978). Very probably larger flares occur only in more complex magnetic field structures such as in August 1972.

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