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SIMULATION OF CURRENT SHEET FORMATION FOR MAY 27, 2003 FLARE USING PHOTOSPHERIC MAGNETIC FIELD

A.I. Podgorny[1], I.M. Podgorny[2]

[1]*Lebedev Physical Institute RAS, Moscow, Russia podgorny@fian.fiandns.mipt.ru,*
[2]*Institute for Astronomy RAS, Moscow, Russia, podgorny@inasan.rssi.ru*

Abstract. MHD simulation of current sheet (CS) formation in the active region 0365 for May 27, 2003 flare is performed. The observed distributions of magnetic field on the photosphere are used for setting initial and boundary conditions. In previous publications the magnetic field of an active region is typically approximated by the field of dipoles or magnetic charges. Such approximations do not permit to take into account all features of an active region.

The mechanism of magnetic energy accumulation for solar flare based on CS formation explains the observed primordial flare energy release high in corona (e.g., [1]) and other main flare manifestations. The observations of magnetic field configuration in corona are now impossible. So to understand the physical mechanism of the solar flare and improve solar flare prognosis it is needed to perform MHD simulations for corona using observed line-of-sight magnetic field maps on the photosphere for setting initial and boundary conditions.

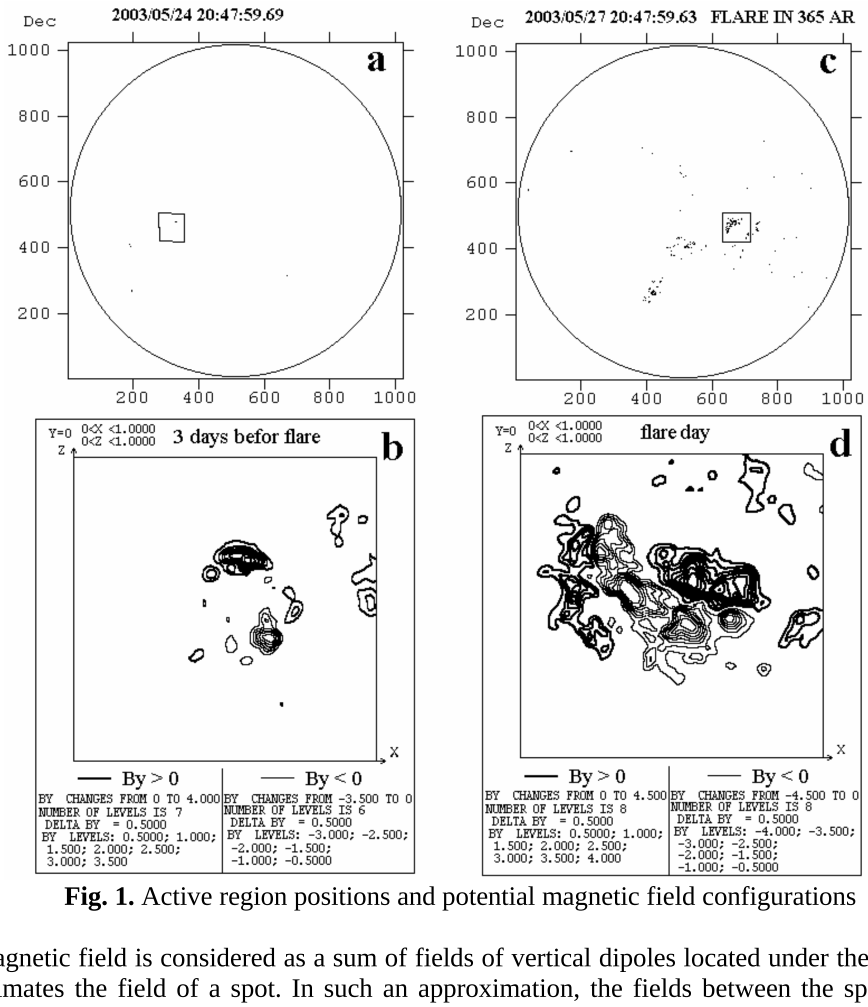

Fig. 1. Active region positions and potential magnetic field configurations

In [2], the magnetic field is considered as a sum of fields of vertical dipoles located under the photosphere. Each of them approximates the field of a spot. In such an approximation, the fields between the spots are not taken into account. In [3], the magnetic field maps are used for setting initial and boundary conditions. But the active region of Bastille flare (July 14, 2000), which is treated in [3], is too complicated and the grid 41×41×41 is too rough. There are shown some tendencies of CS formation by disturbances focusing in the solar corona. Here we perform calculations for a smaller and taken in a simpler form active region, which produced May 27, 2003 flare. The calculations are performed with more detailed grid 101×51×101.

For a more accurate simulation, it is planned to use magnetic field vector distribution on the photosphere, when the data are available. Now the magnetic field components parallel to the photosphere, which are needed for setting boundary conditions for MHD equations, are taken from the potential field, which is calculated using line-of-sight magnetic field distribution. Such a procedure is possible because CS forms high above the photosphere, and its magnetic field does not disturb much the photospheric field. For this purpose the Laplace equation with inclined derivative as the boundary condition is solved numerically. SOHO MDI line-of-sight magnetic field maps are used. The MHD equations are solved using absolutely implicit and conservative with regard to magnetic field finite-difference scheme, which is realized in program PERESVET. The dimensionless equations, numerical techniques and initial-boundary problem are described in [3, 4]. Additionally, there are used specially developed techniques, which permit to stabilize the solution near the photospheric boundary where strong magnetic field gradients can initiate a numerical instability.

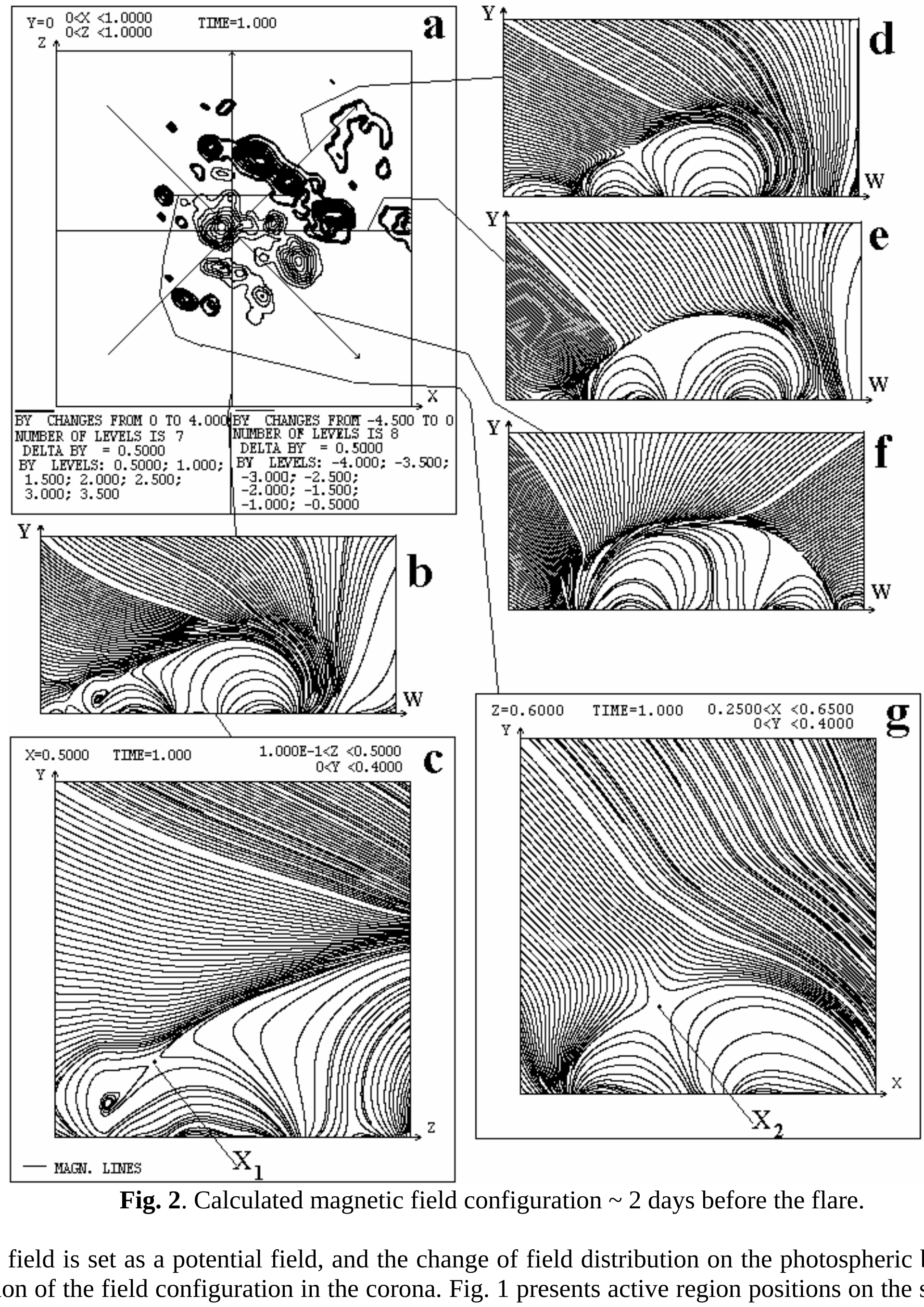

Fig. 2. Calculated magnetic field configuration ~ 2 days before the flare.

The initial field is set as a potential field, and the change of field distribution on the photospheric boundary causes the evolution of the field configuration in the corona. Fig. 1 presents active region positions on the solar disk 3 days before the flare (a) and on the day of the flare (c) and the lines of level of the normal to the photosphere potential field distributions (b) and (d).

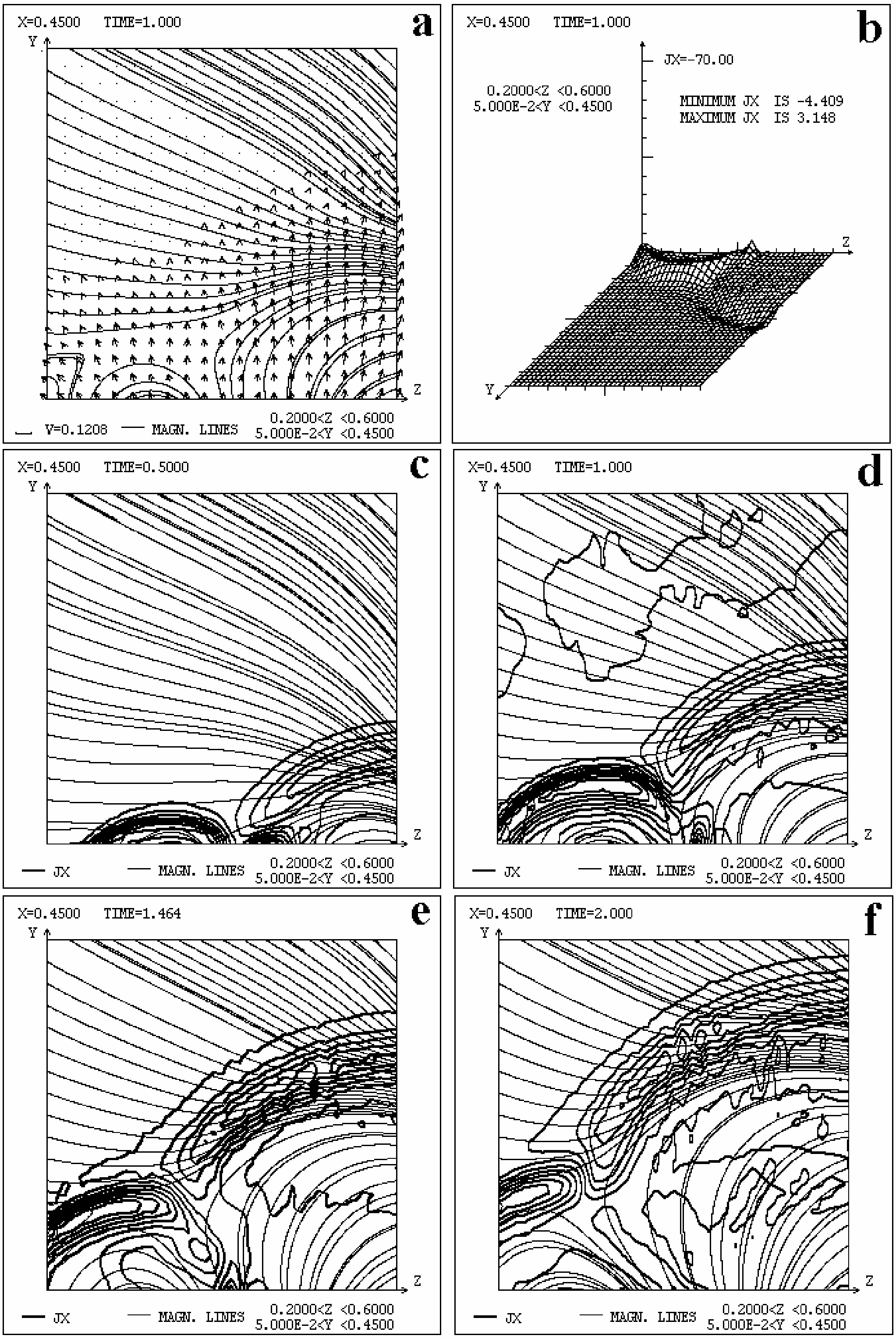

Fig. 3. For the region shown in Fig. 2c: a – magnetic lines with the velocity vectors, b – current density distribution, c-f – time evolution of magnetic lines with current density lines of level.

Figure 2 presents calculated magnetic field configurations in the corona two days before the flare in the planes perpendicular to the photosphere, which intersect the photosphere through the lines shown in Fig. 2a. At that time, two singular lines appear above the active region. One CS can form later in the vicinity of the singular line that intersects the figure plane in the point X_2, which is shown in Fig 2g. A CS also forms in the vicinity of line X_1 shown in Fig. 2b (the same configuration in more detail is given in Fig. 2c). Parameter distributions near this CS and its time evolution for ~ 1 – 2 days before the flare are shown in Fig. 3. Apparently, this CS is responsible for the small flare that occurs ~ 1 day before the main flare on May 27, 2003. Figure 4 shows that near the time of the main flare, a CS also forms in the vicinity of line X_2 (Fig. 2g).

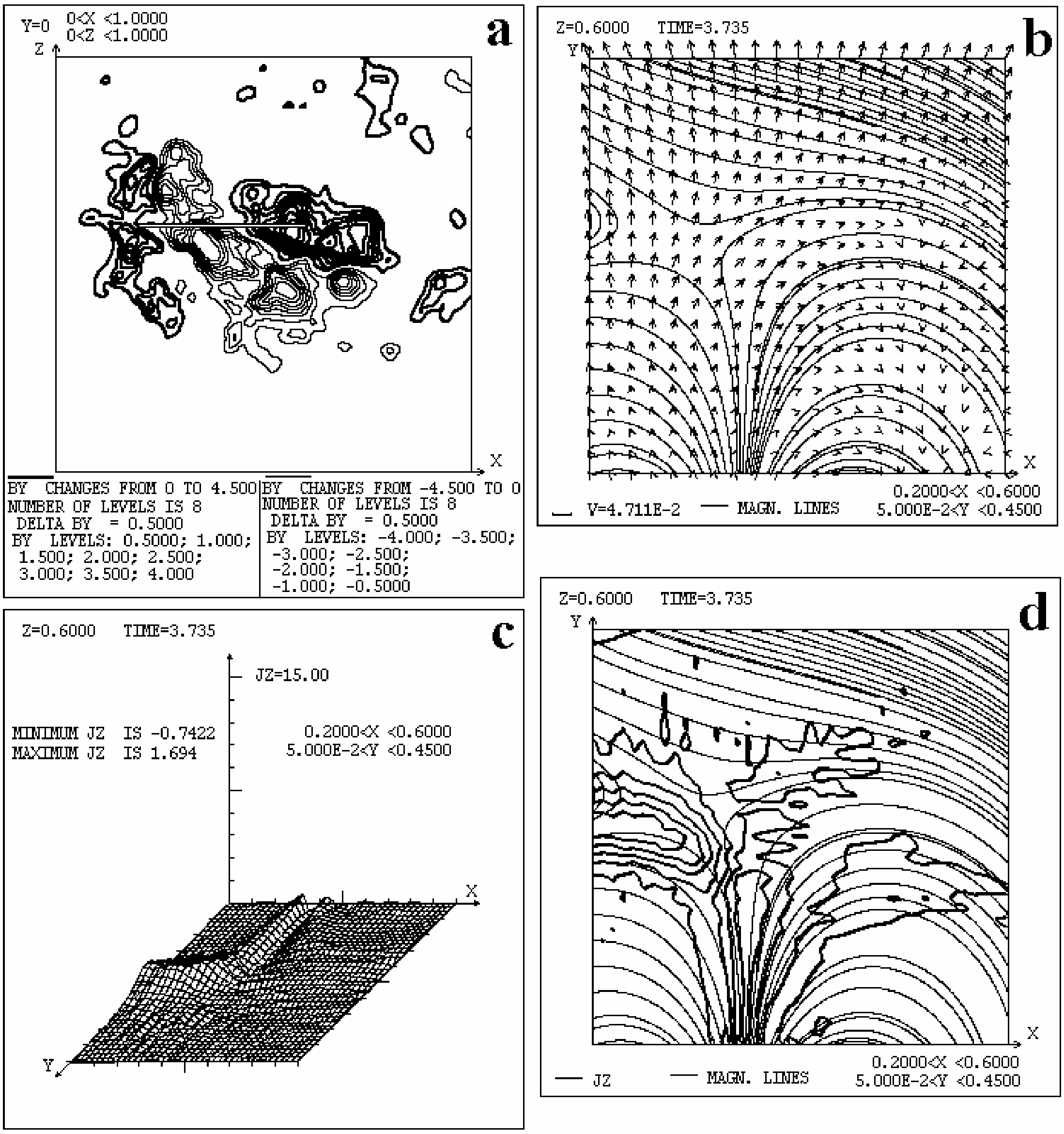

Fig 4. In the plane shown in (a): b - magnetic lines with velocity vectors, c - current density distribution, d - magnetic lines with current density lines of level.

Conclusion. The simulation shows that CS formation takes place in the active region, which produce the flare. Further, we are planning to compare the position of calculated CS with the location of the flare found from the observations of radio and X-ray radiation. To apply this kind of simulations to flare prognosis, it is necessary to advance the numerical technique in order to obtain stable solutions rapidly enough.

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