B. V. Somov. *New theoretical models of solar flares.* In the last decade, especially during the coordinated international program of the Solar Maximum Year (1981), studies of solar flares have acquired a comprehensive and complex character (see, for example, Ref. 1). The flow of the most diverse observational data on flares and the secondary phenomena caused by them has made it possible to obtain new and significantly more detailed information on the mechanism of flares.[2] Theoretical ideas concerning solar flares have also been significantly refined and partially changed.[3]

The results of the Solar Maximum Year showed primarily that most of the energy of a flare is released not in accelerated particles, as previously thought, but rather in the form of intense fluxes of heat into a high-temperature, relatively dense plasma. Since this energy derives from the strong magnetic fields in the sun's atmosphere, the problem of rapid dissipation of electric currents forming thin layers in the highly conducting plasma has become even more urgent.[4] Great hopes have for a long time been placed on the process of magnetic reconnection—the interaction of the magnetic fields with antiparallel components (see, for example, Ref. 5).

In connection with new observational data indicating magnetic reconnection in solar flares,[6] the development of a self-consistent model of high-temperature turbulent current layers (HTCL) was undertaken about five years ago at the P. N. Lebedev Physics Institute.[7] The model takes into account the following three effects, which are characteristic of the process of magnetic reconnection in flares and other nonstationary phenomena in the sun's atmosphere.

First, the current layer is usually not "neutral," i.e. having only strictly antiparallel magnetic-field components. The presence of at least a small transverse component in the layer substantially increases the effectiveness of the cooling of the HTCL by convective plasma and anomalous heat flows. Moreover, a self-consistent analysis of the HTCL shows that both the plasma outflow from a layer and plasma inflow into it increase. The flow of magnetic energy dissipated in the HTCL increases together with the flow of plasma into it. This yields a quite intense energy release with relatively low characteristic reconnection velocities.[8]

Second, modern observations demonstrates the strong nonuniformity of the plasma in flare loops, especially across them, i.e., preferably across the magnetic lines of force. Under these conditions, as is well known,[9] excitation of so-called gradient instabilities must be expected. Amongst these instabilities the most important ones for solar flares are those leading to anomalous diffusion of plamsa and heat across the magnetic field.[10]

Finally, the model of the HTCL takes into account the fact that under real conditions "zero lines" of the magnetic field do not exist on the sun, and magnetic reconnection is always realized in the presence of a longitudinal (with respect to the current in the layer) magnetic field. The current layers form on the so-called "limiting lines"[4] or "separators."[11] The latter differ from the zero lines only by the presence of a longitudinal magnetic field.

The appearance of separators in the sun's atmosphere was previously usually attributed to the surfacing of a new magnetic flux from the photosphere in the region where a magnetic field already exists. It can be shown with the following example that the presence of separators must be viewed as a much more general phenomenon. Figure 1a ex-

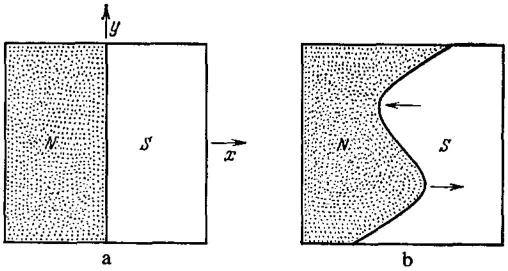

FIG. 1. Model distribution of the vertical component of the magnetic field in the photosphere.

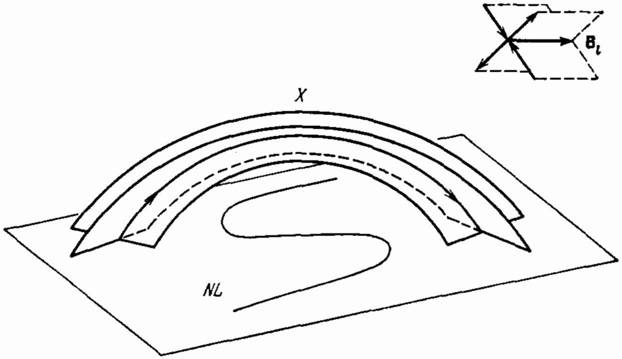

FIG. 2. Topologically singular line of force of the potential magnetic field—the separator (x)—above the S-shaped bend of the photospheric neutral line (NL). The inset in the upper righthand corner shows the structure of the magnetic field near the separator. $\mathbf{B}_l$ is the longitudinal component of the magnetic field along the separator.

hibits the simplest variant of the distribution of the vertical component of the magnetic field in the photosphere. The interface between fields with opposite polarity—the neutral line—divides the region of the source along the y axis. In accordance with the fact that it is often visible in solar magnetograms, this region is deformed by photospheric flows, which gradually acquire the shape of the letter S (Fig. 1b).

At first glance it appears that the magnetic field with such simple sources in the photosphere cannot in principle have any topological singularities. This, however, is not so. Beginning with some critical bending of the neutral line, the field calculated in the potential approximation contains an important topological singularity—a separator (Fig. 2) and, in the general case, does not contain any zero points.

In the presence of a longitudinal magnetic field different sides of the reconnection process have a considerably different appearance. The compression of the longitudinal field leads to the appearance of an electric current circulating in the transverse (with respect to the main current) section of the layer. This current creates under the conditions of finite conductivity a strong (if the compression is large) Joule heating of the plasma in the layer. It is important, however, that this heating is ultimately realized due to dissipation of the principal or reconnecting components of the field, while the flux of the longitudinal field is conserved, in spite of the dissipation of the circulating current.[12]

The solution of the problem of solar flares promises much for the understanding of a wide range of phenomena in cosmic and laboratory plasmas. It is also necessary for the development of scientifically well-founded, reliable forecasting of the radiation environment in interplanetary space. In this connection, it is not surprising that large scientific groups in the West are studying the problem of flares. It is no accident that solar flares are of interest to astronomers and physicists, biologists and medical doctors, climatologists and energy specialists. A successful development of the theory of solar flares in our country could serve as a good foundation for further theoretical and experimental research on this interesting and important natural phenomenon.

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