Scientific session of the Division of General Physics and Astronomy and the Division of Nuclear Physics of the Academy of Sciences of the USSR (26–27 September 1984)

Usp. Fiz. Nauk **145**, 529–544 (March 1985)

A joint scientific session of the Division of General Physics and Astronomy and the Division of Nuclear Physics of the USSR Academy of Sciences was held on September 26 and 27, 1984 at the P. N. Lebedev Physics Institute of the USSR Academy of Sciences. The following reports were heard at the session:

26 September

1. *S. I. Gopasyuk.* Dynamics of the magnetic field, electric currents, and flares in active regions on the sun.

2. *I. A. Zhitnik,* S. L. Mandel'shtam, I. P. Tindo, and A. M. Urnov. New observational data on x-ray flares and active regions on the sun.

3. *B. V. Somov.* New theoretical models of solar flares.

27 September

4. *S. M. Klotsman.* Role of defects in the formation of the properties of metals.

5. *V. A. Trapeznikov.* Study of surface layers by the method of electron spectroscopy.

6. *V. G. Chudinov.* Computer simulation of radiation processes.

The brief contents of the reports are published below.

S. I. Gopasyuk. *Dynamics of the magnetic field, electric currents, and flares in active regions on the sun.* As first discovered by A. B. Severnyĭ,[1] solar magnetic fields are concentrated in separate filaments around which electric currents flow. The transverse size of these structures often attains 5″. It is by no means clear, however, what is the fine structure of these formations, because the earth's atmosphere limits the resolution.

The structure of the fields in the active region changes significantly with time because of the rotation of the spots around an axis and because of the relative motion of the spots.

The spot rotation causes the force lines of the magnetic field to twist into a spiral, and all the more quickly the higher is the rotational velocity of the spot. The lines of force of weak fields are twisted more strongly than those of strong fields. The rotation of a spot in the opposite direction leads to untwisting of the lines of force previously twisted into a spiral. Torsional oscillations are sometimes observed in a filament of the magnetic field, forming a pair of spots on the sun's surface. The period of such oscillations is approximately six days.

The characteristic motions of the spot cause a reorientation of the lines of force of its magnetic field: the lines of force are deformed and compressed in front of the moving spot and they stretch out behind the spot along the trajectory. The relative motion of the spots does not destroy the magnetic coupling between them, though the structure of the field can become extremely complicated.

The disturbances of the magnetic field in the photosphere of the active region are associated with electric currents flowing in the upper layers of the solar atmosphere.[2]

According to studies by A. B. Severnyĭ,[3] the flares strive to appear at locations in the active region where strong rotaformed into the energy of the observed manifestations of the flare? Many more or less convincing theoretical models, which will be discussed by B. V. Somov, exist, but we do not know what happens in reality.

In this report the results obtained in recent years from observations of x-ray emission of flares are described. The x-ray emission is characterized by the electronic component of the plasma and is therefore most closely linked to the primary processes involved in the energy release in flares.

As a rule, two phases appear in a flare: the "pulsed" phase, whose duration varies from several seconds to several minutes, and the "smooth" phase, whose duration varies from several minutes to tens of minutes and several hours. The pulsed phase is characterized by a sharp growth of the hard x-ray ($E \approx 20$–30 keV, and sometimes with energies up to several hundreds of keV) emission; H_α and far ultraviolet emission begin to grow, and type III radial bursts also appear. In the smooth phase soft x-ray ($E \lesssim 10$ keV), microwave, and H_α emissions increase and then drop-off slowly. Very recently, because of the increase in the sensitivity of detectors, the pulsed phase was also observed in the soft x-ray emission, and the smooth phase was observed in the hard x-ray emission.

The results of x-ray observations in the soft and hard regions—measurements of the fluxes, detection of images of the flares, study of spectra and polarization of the continuous and line emission—lead to the following probable scenario of the development of a flare. When the local magnetic field in the active region changes (surfacing of a new magnetic tube, restructuring of the existing field, for example as a result of the motion of matter, etc.), a primary transfer of part of the magnetic energy into the thermal energy of the plasma and part of the energy into the directed motion of electrons with energies of ≈ 20–30 keV apparently occurs at

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the top of the magnetic loops in the corona at an altitude of 30–60 thousand km. Some of these electrons escape from the sun's atmosphere, giving rise to the appearance of type III radial bursts as they pass through the corona. The remaining accelerated electrons move along magnetic lines of force in the chromosphere. The energy which is transformed into the directed motion of the electrons and into the thermal energy of the plasma apparently changes from flare to flare and during the development of a flare. The order of magnitude of the energy transformed into the directed motion of electrons is 10^{-1} of the total energy of the flare. The electrons, while moving downwards, give rise to hard polarized x-ray bremmstrahlung at the base of the loops. The magnitude of the polarization depends strongly on the pitch angle and velocity distribution of the electrons and thus varies over a wide range.

The energy flowing into the plasma heats part of the plasma with an emission of $Y \approx 10^{47}$ cm^{-3} up to $T_e \approx 2 \cdot 10^7$ K. The appearance of hotter nuclei with $T_e \sim 10^8$ K but with lower emission has not been excluded; such formations, however, have not yet been observed. As energy is released tions of the transverse magnetic field vector and crossing of fields of different orientations (primarily transverse) occur. At these locations the electric currents are maximum. The magnetic-field gradients there often attain magnitudes of 0.1 G/km. Gradients of this magnitude correspond to electric current densities of 10^4 A/km^2. The intensity of a flare is in general determined by the magnitude of the field gradient or the electric current density.

The motions of spots are intensified prior to the appearance of a flare and during the course of its development. Flares appear at locations toward which, among other things, spots and humps in the magnetic field predominantly move. The appearance of flares is closely linked to the rotation of the spots. Disturbances of the magnetic field arising from the rotation and relative motion of the spots in the active region create the characteristic features of the plasma state and intensification of electric currents with which the appearance of flares is probably associated.

Two types of flares can appear. The first type is associated with excitation accompanying the rotation of the spots (magnetic filaments). This type of flare corresponds best to the point of view developed by H. Alfvén and P. Carlquist.[4]

The second type is associated with the motion of the spots. It corresponds best to current layers.

During an intense flare the energy stored in the magnetic field in the active region decreases by 10^{32} ergs. The change in the magnetic flux along the contour of the active region creates an emf which is sufficient to accelerate particles up to 10^8–10^9 eV.[5]

[1]A. B. Severnyĭ, Izv. Krym. Astrofiz. Obs. **33**, 34 (1965).

[2]S. I. Gopasyuk, B. Kalman, and V. A. Romanov. Izv. Krym. Astrofiz. Obs., *ibid*. **72**.

[3]A. V. Severny in: Solar Flares and Space Research, edited by C. De Jager and Z. Svestka, Amsterdam (1969), p. 38.

[4]H. Alfvén and P. Carlquist, Solar Phys. **1**, 220 (1967).

[5]A. B. Severnyĭ in: Solar Magnetic Fields, edited by R. Howard, D. Reidel, Dordrecht (1971), p. 417.