Stellar associations are observed in these galaxies. If the bar is enclosed in a ring, there are no dark bands in it. This means that there is no appreciable relative motion of the gas in the disk and the bar, i.e., that the gas, like the bar, rotates as a solid body. The problem of the bars is still far from solution.

Most arms of spiral galaxies are density waves. However, certain finer details may exist in the form of permanent (nonwave) condensations of gas that have been stretched out by differential rotation. The Orion arm is thought to be such a condensation. This may be confirmed by the specific screw-type structure of its magnetic field, while the lines of force of the Galaxy take an approximately tangential direction. The screw structure could not be preserved if this arm were a density wave.

Some of the results that the author reported have been published in[6,8,11], and the rest are being prepared for publication.


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**S. L. Mandel'shtam.** Polarization of the Emission of X-ray Flares on the Sun and their Spectra

Among the remarkable manifestations of solar activity is the so-called solar "flare"--a sudden strong brightening of a certain area of the solar surface that is especially conspicuous in the light of the $H_\alpha$ spectral line and occurs in active regions associated with magnetic spots. It was established with the development of radio astronomy that optical flares are accompanied, as a rule, by outbursts of radio emission in the centimeter, decimeter, and meter bands. Instruments lifted outside the earth's atmosphere on satellites and rockets have made it possible to detect flares of x-radiation, as well as bursts of accelerated electrons, protons, heavy nuclei, and plasmoids. Solar flares cause a number of effects on the earth and in the space around it—disturbance of radio communications, magnetic storms, etc., and also present a radiation hazard for cosmonauts. Investigation of solar flares is important for understanding of the physical processes on the sun and for the entire range of problems in the relation of the sun to the earth.

Detailed study of the x-ray emission of solar flares is of great importance for understanding of their mechanism. X-rays appear as a result of interaction between fast electrons and ions in the region of the flare, in the form of bremsstrahlung and recombination continuous and line-spectrum emission of the ions. Study of the x-ray emission of flares will make it possible to determine the physical parameters of the plasma—its electron and ion temperatures and particle densities—and the localization, dimensions, and structure of the x-ray-flare regions.

The paper presents the results of studies of x-ray flares made at the P. N. Lebedev Physics Institute, USSR Academy of Sciences, by a group composed of I. L. Beĭgman, L. A. Vaĭnshteĭn, B. N. Vasil'ev, I. A. Zhitnik, V. D. Ivanov, V. V. Krutov, S. L. Mandel'shtam, I. P. Tindo, and A. I. Shurygin with data from the satellites "Interkosmos 1" (launched October 14, 1969) and "Interkosmos 4" (launched October 14, 1970).

In the x-ray emission of flares, special interest attaches to a pulsed component with photon energy $h\nu \approx 10$–20 keV, a rise time of several seconds, and a duration in the tens of seconds. Since it can be assumed that particles are accelerated and plasma is expelled during the pulsed phase of an x-ray flare, it is highly important to ascertain the mechanism by which the hard x-radiation arises: does it result from heating of the plasma to high temperature, or is it due to directional streams of accelerated electrons arising in or invading the region of the flare?

A direct approach to clarification of this question is measurement of the polarization of this radiation: if the x-ray emission is due to a directional electron beam, it will be partially polarized, otherwise not (the quantitative calculations of the polarization were performed by A. A. Korchak).

The measurements that were made indicated the presence of distinct polarization of the x-ray emission in the initial phase of the flares, as well as during the second emission maximum. By way of example, Fig. 1 shows the results of measurements for a class 2 x-ray flare of November 16, 1970: the radiant flux in the 15–20-keV range (a), the polarization of the radiation (b), and the polarization angle (c). The accelerated directional electrons are thermalized during the decaying phase of the flare, and the polarization vanishes.

Information on plasma parameters in x-ray-flare regions was obtained from study of the line spectra of the flares in the 1–15-Å range. Figure 2 represents a segment of the spectrum of a class 3 x-ray flare of November 16, 1970 around 1.8 Å, showing lines of helium-like and lithium-like iron ions. The spectra of Fe XXIII-Fe XXV have not yet been reliably obtained under laboratory conditions; the lines were identified by comparison with the results of theoretical calcula-

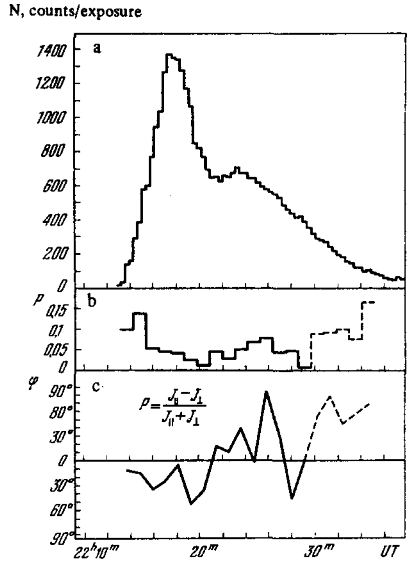



FIG. 1

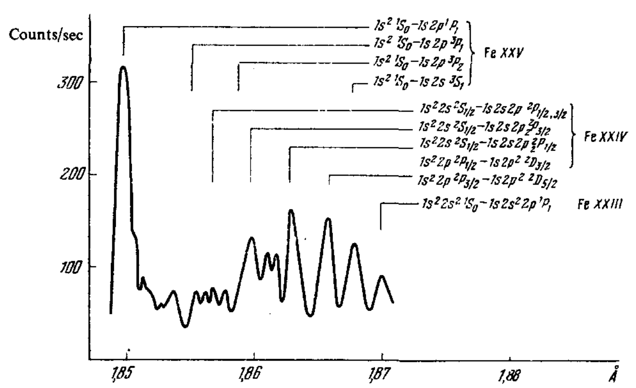



FIG. 2

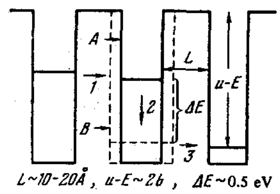
tions of the line wavelengths (calculations performed by U. I. Safronova).

The electron temperature of the flare region was determined at $T_e \approx 20 \times 10^{6}$°K from the relative intensity of the lines of Fe XXV at $\lambda = 1.850$ Å and Fe XXIV at $\lambda = 1.886$ Å, and according to the Doppler broadening of the lines of Mg XII at $\lambda = 8.418$ Å and Fe XXV at $\lambda = 1.850$ Å, the ion temperature $T_i \approx 16 \times 10^{6}$°K.

X-ray flare regions have a drawn-out filamentary structure with bright nodes that changes rapidly in time; the filament length $\approx 100''$, the diameter $\leq 10$–$20''$, and the electron density $\approx 10^{10}$–$10^{11}$ electron/cm$^3$. The height and structure of the x-ray-flare regions were found to be very close to those of optical flares, indicating an intimate relation between x-ray and optical flares.

**D. S. Chernavskiĭ.** Modeling of Certain Biological Processes.

The paper is concerned with the application of methods of theoretical physics to solution of certain biological problems. There are currently several aspects of this effort. We shall examine two of them:




1) Physical aspects of biochemical processes.
2) Mathematical modeling (more precisely, mathematical models of the kinetics of biological processes). We cite a few examples.

The first pertains to electron transport, which is the basis of the supply of energy to the cell, i.e., the formation of ATP. It consists in the following. An electron is excited in a certain molecule (in plants, this is the chlorophyll molecule, and excitation is by a quantum of light). The electron is then transferred to other, transferror molecules; its level is lowered. In some molecule, the lowering of level is accompanied by transformation of energy to other forms (in the final analysis, to chemical form—formation of ATP). The transferrors are macromolecules with dimensions in the tens of Angstrom units; they are situated in the membrane and fit tightly into one another. A diagram illustrating the process appears in the figure.

The physical aspect of the question is that of how the electron is transferred—by jumping over the barrier or tunnelling through it. Tunneling appears more likely for a number of reasons, but two objections have been raised to this: 1) it was assumed that the rate of tunneling should not depend on temperature (a dependence with activation energy on the order of 0.14 eV has been observed experimentally[1]); 2) extremely precise (practically unattainable) coincidence of the levels is necessary for tunneling.

It was shown in[2] that both of these objections are answered when the binding of the electron with a small number of normal oscillations is considered: the level difference may reach 0.1 eV (the characteristic magnitude of the normal-oscillation energy); the rate of the process depends on the presence of normal oscillations and, consequently, on temperature (the activation energy is of the same order, 0.1 eV).

A physical model of the chief event—transformation of energy—was examined in[3]. The molecule of the transformer-transferror may be in either of two forms: A—an equilibrium form in the absence of the electron and B—an equilibrium form in its presence; the level of the electron is higher in A than in B.

The energy-transformation process consists of the following stages (see Figure): (1) an electron from a preceding transferror tunnels into the transformer molecule: A + e → Ae. (2) The state Ae relaxes to equilibrium: Ae → B; the change in the form of the molecule is accompanied by a lowering of the level. (3) The electron tunnels into the next transferror, whose level is close to the level B. The state B contains an excess of energy, since its form (and the disposition of its active groups) are nonequilibrium; this form of the energy may be transformed to chemical, as happens in (4): the relaxation B − e → A. Thus, the energy goes from the form of electronic excitation to deformation energy and thence to chemical bonding energy.