SOVIET PHYSICS USPEKHI VOLUME 14, NUMBER 6 MAY-JUNE, 1972

530

SCIENTIFIC SESSION OF THE DIVISION OF GENERAL PHYSICS AND ASTRONOMY, USSR ACADEMY OF SCIENCES

(April 28–29, 1971)

Usp. Fiz. Nauk **105**, 769–775 (December, 1971)

A scientific session of the Division of General Physics and Astronomy of the USSR Academy of Sciences was held on April 28 and 29, 1971 in the Conference Hall of the P. N. Lebedev Physics Institute. The following papers were delivered:

1. V. A. Krat, First Results from the Third Flight of the Soviet Solar Stratospheric Observatory.
2. V. N. Kuril'chik, Relativistic Electrons in Extragalactic Radio Sources.
3. Yu. N. Denisyuk and V. I. Sukhanov, Holography in Two-dimensional and Three-dimensional Media.
4. M. I. D'yakonov, B. P. Zakharchenya, V. I. Perel', S. I. Safarov, and V. G. Fleĭsher, Orientation of Electron Spins in Semiconductors.
5. Yu. M. Gal'perin, P. E. Zil'berman, S. N. Ivanov, V. D. Kagan, and G. D. Mansfel'd, A New Type of Acoustoelectric Nonlinearity (Nonlinear Landau Damping of Sound Waves).

We publish below brief contents of the papers.

V. A. Krat. First Results from the Third Flight of the Soviet Solar Stratospheric Observatory.

During the third flight (July 30, 1970) of the Soviet stratospheric solar observatory, 93 photographs of the sun's photosphere were obtained with unsurpassed resolution (the theoretical limit of resolution for a Cassegrain telescope with a 50-cm primary mirror). Twenty spectrograms with resolution double that of the best spectrograms recorded on the ground were also obtained.

The basic results obtained on reduction of some of the material collected reduce, briefly stated, to the following:

1. Comparison of 15 photographs of a series taken of a large sunspot in group No. 359 (numeration according to the "Solar Data") showed that changes can be observed even within two minutes both in the nucleus of the spot and in its penumbra. The strongest changes occur in the nucleus of the spot, which undergoes a complete change in structure in 40 min. The structure of the nucleus changes more rapidly than that of the penumbra. The nucleus has nothing structural in common with the granulation and presents an inhomogeneous continuous background with stellate inclusions. The structural elements were analyzed photometrically. This phenomenon is interpreted as the beginning of dissipation of the sunspot's magnetic field into individual strands of the facular or magnetic-bundle type.

2. The photometric analysis of the penumbra and nucleus structural elements of the sunspot has convinced us that the average coefficient of opacity in sunspots should be higher than the value usually assumed. The average brightness fluctuation of the photospheric granulation is 8.8%, but 11% after correction for the contrast frequency response of the instrument.

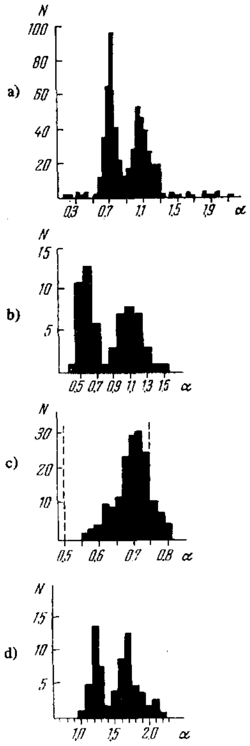
3. A preliminary analysis of the radial velocities of the granulation according to the spectrograms, with recognition of the fact that large brightness gradients are observed at high resolution between the granules and the spaces between them—gives a satisfactory explanation of the blue-shift effect at the center of the disk, which obscures the Einstein effect.

4. It was observed that a velocity gradient exists in the dark intervals between granules and increases with height in the atmosphere. The correlation between the brightness distribution in the photosphere and the radial velocities is violated in the upper atmospheric layers.

5. It is shown that outside of the active processes, the average dimensions of the chromospheric elements are nearly twice as large as those of the small photospheric elements, and are represented by effective diameters of 500–600 km.

V. N. Kuril'chik. Relativistic Electrons in Extragalactic Radio Sources.

Analysis of the continuous radio-emission spectra of extra-galactic objects (quasars, radio galaxies, normal spiral galaxies) speaks convincingly in favor of a discretely continuous distribution of the spectral indices α (the exponents in the frequency dependence of the spectral flux density of the radio emission $F_\nu \sim \nu^{-\alpha}$), which characterize the power-law energy spectra of relativistic electrons emitting by the synchrotron mechanism $N(E)dE \sim E^{-\gamma}dE, \gamma = 2\alpha + 1$).



a) Distribution of spectral indices encountered among objects in 3CR catalogue; b) same, for radio-emission spectra of normal spiral galaxies; c) spectral-index distribution of objects in 3CR catalogue in the first maximum; spectra whose indices may be clearly high owing to the influence of halo-like radio structures have been eliminated; the dashed lines indicate the theoretical limits of the distribution; d) distribution of spectral indices of the spectra of halo-like radio structures of objects in catalogue 3CR.

The discreteness of the values of α and the γ corresponding to them is manifest in a distinct grouping of these values around 0.7, 1.2, and 1.7 in the case of the radio structures of powerful radio sources (radio galaxies, quasars)[1-4] and near 0.6 and 1.1 in the case of weak radio sources in normal spiral galaxies[5] (Figs. a–d).

Continuity is manifested in the distribution of the α values in the fact that, for example, the most representative group of first-maximum spectra shows a real scatter of the indices in the range $0.5 < \alpha_0 \leq 0.75$ (Fig. c). This last fact suggests that the indices of the relativistic-electron energy spectra of this group of spectra are subject to the relation obtained by S. I. Syrovatskiĭ[8], namely that the energy spectra have the form $N(E)dE \sim E^{-\gamma_0}dE \sim E_{-(2+\delta)}dE$, where

$$\delta = \frac{W_{\text{c.r}}}{W_H + W_{\text{turb}}}$$

is the cosmic ray energy in the region of their acceleration expressed as a fraction of the sum of the energy densities W_H of the magnetic field and W_{turb} of the turbulent motion of the gas ($W_H \approx W_{\text{turb}}$). The parameter δ can vary in the range $0 < \delta \leq 0.5$, which corresponds to $2 < \gamma_0 \leq 2.5$ ($0.5 < \alpha_0 \leq 0.75$). The good agreement between the theoretically expected and observed distributions of the indices α_0 indicates that this group of radio-emission spectra characterizes the initial relativistic-electron spectra generated by extragalactic objects (by their nuclei).

The larger discrete values of the spectral indices, which characterize the high-frequency segments of the spectra of a number of radio structures, are the derivatives of the initial spectra with successive 0.5 increases in α_0 ($\alpha_0 + 0.5$ and $\alpha_0 + 0.5 + 0.5$), to which unit changes of γ_0 correspond ($\gamma_0 + 1$ and $\gamma_0 + 1 + 1$).

The aggregate of the observational data indicates that the first knee in the energy spectrum ($\gamma_0 \rightarrow \gamma_0 + 1$) has most probably been formed in the generation process of the relativistic electrons in the nuclei of the galaxies and quasars under quasistationary acceleration and radiative energy loss conditions. Under the conditions of quasistationary electron pumping and losses of electron energy to radiation in radio structures external to the nuclei, the second knee is formed with an additional change in the exponent γ by unity ($\gamma_0 + 1 \rightarrow \gamma_0 + 2$) in the high-energy parts of their spectra. On the whole, over the aggregate of the objects, the average relativistic-electron spectrum takes the universal form

$$N(E)\,dE = K_1 E^{-\gamma_0}\,dE, \qquad E_1 < E < E_2,$$
$$N(E)\,dE = K_2 E^{-(\gamma_0+1)}\,dE, \quad E_2 < E < E_3.$$

Here the energy $E_1 \geq 5 \times 10^6$ eV, $E_2 \approx (1-5) \times 10^9$ eV, $E_3 = E(t) \geq 10^{10}$ eV for the main (for example, double) radio structures.

In the halo-like radio structures of a number of powerful radio sources (as a rule, objects with double main radio structures), under conditions of quasistationary pumping of electrons into these structures, the synchrotron and Compton losses to the microwave metagalactic background radiation form a spectrum of the type

$$N(E)\,dE = K_3 E^{-(\gamma_0+2)}\,dE, \quad E_2 < E < E_3.$$

If the submillimeter and infrared (SM and IR) radiation of a number of nuclei of Seyfert galaxies and quasars is of synchrotron nature under conditions of effective trapping of the relativistic electrons by the magnetic field of the nucleus, then with preservation of the adiabatic invariant by the relativistic electrons in motion in this field, we may expect spectral indices $\alpha = (2\gamma_0 + 1)/3 \approx 1.66-2.0$[6] in the optically thin part of the spectrum, a close approximation of the nature of the observed spectra[7]. Under conditions of a chaotic field and motion of electrons without preservation of the adiabatic invariant (isotropization on inhomogeneities), the observed steep SM and IR emission spectra of the nuclei may be a consequence of cutoff of the electron energy spectrum owing to synchrotron and Compton energy losses (cutoffs around $E \approx 10^8$ eV). The emission spectrum could then assume any slope up to exponential.

---

[1] V. N. Kuril'chik, Astron. Zh. **47**, 787 (1970) [Sov. Astron.-AJ **14**, 630 (1971)].

[2] V. N. Kuril'chik, ibid. **48**, 684 (1971) [Sov. Astron.-AJ **15**, 542 (1972)].

[3] V. N. Kuril'chik and A. V. Kozenko, Astron. Tsirk. No. 565 (1970).

[4] V. N. Kuril'chik, ibid. No. 579, 1 (1970).

[5] N. A. Komarov and V. N. Kuril'chik, ibid. No. 590 (1970).

[6] N. S. Kardashev, Astron. Zh. **39**, 393 (1962) [Sov. Astron.-AJ **6**, 317 (1962)].

[7] D. E. Kleinmann and F. J. Low, Astrophys. J. Lett. **159**, 165 (1970).

[8] S. I. Syrovatskiĭ, Zh. Eksp. Teor. Fiz. **40**, 1788 (1961) [Sov. Phys.-JETP **13**, 1257 (1961)].