Scientific Session of the Division of General Physics and Astronomy, USSR Academy of Sciences (20-21 March, 1974)

Usp. Fiz. Nauk 113, 728-736 (August 1974)

A scientific session of the Division of General Physics and Astronomy of the USSR Academy of Sciences was held on March 20 and 21 at the conference hall of the Academy of Sciences Institute of Physics Problems. The following papers were delivered:

1. A. V. Gurevich, Nonlinear Effects in the Propagation of High-Power Radio Waves in the Ionosphere.

2. I. S. Shlyuger, An Experimental Study of Nonlinear Effects in the E and F Layers of the Ionosphere.

3. V. V. Vas'kov and A. V. Gurevich, Excitation of Instability of the F Region of the Ionosphere in a Powerful Radio-Wave Field.

4. V. V. Belikovich, E. A. Benediktov, G. G. Getmantsev, L. M. Erukhimov, N. A. Zuĭkov, G. P. Komrakov, Yu. S. Korobkov, D. S. Kotik, N. A. Mityakov, V. O. Rapoport, Yu. A. Sazonov, V. Yu. Trakhtengerts, V. L. Frolov, and V. A. Cherepovitskiĭ, Nonlinear Effects in the Upper Ionosphere.

5. S. M. Grach, A. G. Litvak, N. A. Mityakov, V. O. Rapoport, and V. Yu. Trakhtengerts, Toward a Theory of Nonlinear Effects in the Ionosphere.

6. A. B. Shvartsburg, Reflection of Strong Radio Waves from the Ionosphere.

We publish below brief contents of the papers.

A. V. Gurevich. Nonlinear Effects in the Propagation of High-Power Radio Waves in the Ionosphere. The present state of the problem is briefly reviewed. The Luxemburg effect, or cross modulation of radio waves that interact in the lower ionosphere (at heights $z \sim 80-100$ km) and do not strongly disturb the ionospheric plasma, was investigated systematically back in the 1940's[1]. Recently, with the increasing power and directivity attained in radio, very strong heating of electrons in the lower ionosphere has become possible: electron temperatures can be increased by an order of magnitude under the action of the wave's electric field. Nonlinear effects are decisive in the propagation of such "strong" radio waves. A theory of these effects was set forth in[2], and they were investigated experimentally in detail in[3].

It has also become possible to bring about strong disturbances of the upper ionosphere at the heights of the F-layer maximum (250—300 km). The effect is strongest in the vicinity of the reflection point of the radio waves. Here the electrons are not only heated, but their concentration distribution is also affected, so that the manner in which the radio waves propagate is strongly distorted. Excitation of parametric instability is of special importance here. The phenomena that arise are generally of complex nature. They are now being investigated intensively, both theoretically and experimentally[3,4].

[1] L. Huxley and J. Ratcliffe, Proc. Electr. Eng. 96 (pt. II), 443 (1949).

[2] V. L. Ginzburg and A. V. Gurevich, Usp. Fiz. Nauk **70**, 201, 393 (1960) [Sov. Phys.-Uspekhi **3**, 115, 175 (1970)]; A. V. Gurevich and A. B. Shvartsburg. Nelineynaya teoriya rasprostraneniya radiovoln v ionosfere (Nonlinear Theory of Radio-Wave Propagation in the Ionosphere), Nauka, Moscow, 1973.

[3] I. S. Shlyuger, Usp. Fiz. Nauk **113**, 729 (1974) [Sov. Phys.-Uspekhi **17**, 613 (1975) (follows immediately below).

[4] W. F. Utlaut and R. Cohen, Science **174**, 245 (1971); G. G. Getmantsev, G. P. Komrakov, Yu. S. Korobkov, L. F. Mironenko, N. A. Mityakov, V. O. Rapoport, V. Yu. Trakhtengerts, V. L. Frolov, and V. A. Cherepovitskiĭ, ZhETF Pis. Red. 18, 621 (1973) [JETP Lett. 18, 364 (1973)]; I. S. Shlyuger, ibid. 19, 274 (1974) [19, 162 (1974)].

I. S. Shlyuger. An Experimental Study of Nonlinear Effects in the E and F Layers of the Ionosphere. The results of a study of nonlinear effects that arise when the ionosphere is sounded with powerful radio pulses are set forth. The measurements date from 1961—1968. The pulses were nearly rectangular in shape and $5 \cdot 10^{-4}$ second wide. The repetition frequency was 25 Hz. The filling frequency of the pulses was $\omega = 8.5 \cdot 10^6$ Hz, which is near the local electron gyromagnetic frequency. The polarization of the wave was strictly fixed: ordinary or extraordinary. The radiated power could be varied continuously within 15—20 sec from the minimum −20 dB to the maximum 0 dB. At the maximum effective power of the radiator, the amplitude of the ordinary-wave field at heights on the order of 100 km exceeded the characteristic value of the plasma field E_p[1] by factors of 5 to 6.

The self-action of the powerful pulse in the ionosphere and its interaction with other radio waves, pulsed and continuous, were investigated. The self-action was manifested in strong distortion of the pulse reflected from the ionosphere. This was because the initial part of the pulse propagates in an undisturbed or weakly disturbed ionosphere (the ionosphere cannot change strongly within a time shorter than 10^{-4} sec). At $t \gtrsim 10^{-4}$ sec, the reflected-pulse amplitude changes rapidly with time due to the changes that occur in the ionosphere, and it arrives at a near-stationary level after $t \sim 2 \times 10^{-4}$ sec. This change in the amplitude of the reflected pulse is a result of its self-action in the ionosphere. With increasing radiated power, the self-action effects become stronger. In the case of an ordinary wave during the day, the stationary level of the signal reflected from the ionosphere did not increase with increasing radiated power ("saturation" effect). The additional nonlinear absorption reached ~20 dB during the day in this case and 4—5 dB at night. On the other hand, the absorption of the extraordinary wave at powers that were not too high (smaller than −10 dB) decreased with increasing radiated power (plasma "transillumination" effect).

The interaction of the powerful pulse with continuously radiated radio waves at frequencies $f^{(1)} = 254$ kHz and $f^{(2)} = 394$ kHz was studied. A sharp change in the ampli-