Scientific session of the Division of General Physics and Astronomy, USSR Academy of Sciences (May 25–26, 1977)

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A scientific session of the Division of General Physics and Astronomy of the USSR Academy of Sciences was held on 25 and 26 May 1977 in the conference hall of the P. N. Lebedev Physics Institute. The following papers were delivered:

1. *G. S. Ivanov-Kholodnyĭ, M. A. Kolosov, N. A. Savich, Yu. N. Aleksandrov,* M. B. *Vasil'ev, A. S. Vyshlov, V. M. Dubrovin, A. L. Zaĭtsev, V. A. Samovol, L. N. Samoznaev, A. I. Sidorenko, A. F. Khasyanov, and D. Ya. Shtern.* The ionosphere of Venus according to the data of the satellites "Venera-9, 10" and some singularities of its formation.

2. *M. A. Kolosov, O. I. Yakovlev, T. S. Timofeeva, E. V. Chub, A. I. Efimov, S. S. Matyugov, A. G. Pavel'ev, A. I. Kucheryavenkov, and I. É. Kalashnikov.* Results of radio sounding of the neutral atmosphere of Venus and bistatic radar study of its surface with the aid of the satellites "Venera-9, 10."

3. *M. A. Kolosov, O. I. Yakovlev, A. I. Efimov, V. M. Razmanov, V. I. Rogal'skiĭ, and V. K. Shtrykov.* Inhomogeneous structure of the plasma near the sun and spreading of the spectrum of the radiowaves, as suggested by the results of radio sounding with the aid of the satellites "Venera-9, 10."

4. *M. A. Kolosov, N. A. Savich, M. B. Vasil'ev, A. S. Vyshlov, V. I. Rogal'skiĭ, V. A. Samovol, and L. N. Samoznaev.* Investigations of the plasma near the sun by the dispersion-interferometer method during the flight of the satellites "Venera-9, 10."

May 26

(Joint session of the Division of General Physics and Astronomy and of the Division of Nuclear Physics of the USSR Academy of Sciences)

1. *A. M. Polyakov.* Properties of vacuum in gauge theories.

2. *V. A. Khoze.* The heavy lepton $\tau^{\pm}$ in $e^{+}e^{-}$ annihilation.

3. *M. I. Vysotskiĭ, A. D. Dolgov, and Ya. B. Zel'dovich.* Cosmological limitations on the mass of neutral leptons.

4. *M. A. Shifman.* Charmonium and asymptotic freedom.

We publish below a brief content of seven of the papers.

G. S. Ivanov-Kholodyni, M. A. Kolosov, N. A. Savich, Yu. N. Aleksandrov, M. B. Vasil'ev A. S. Vyshlov, V. M. Dubrovin, A. L. Zaĭtsev, V. A. Samovol, L. N. Samoznaev, A. I. Sidorenko, A. F. Khasyanov, and D. Ya. Shtern. *The ionosphere of Venus from the data of the satellites "Venera-9, 10" and some singularities of its formation.* 1. The launching of the space ships "Venera-9, 10" on the orbits of the satellites of Venus has made it possible to realize for the first time a repeated two-frequency sounding of the ionosphere of this planet. The procedure used in these experiments, which were performed from 24 October through 7 December 1975, was analogous to that used in the study of the ionosphere of Mars.[1] During that time the conjunction of the sun, of Venus, and of the earth were such that the "sun–Venus–earth" angle was close to a right angle and the radio sounding of the ionosphere of Venus took place when the satellites set behind the planets in the region of the midnight meridians and rose in the region of the noontime meridians. The zenith angles of the sun in the sounded regions were in the range $10° \lesssim z_{\odot} \lesssim 166°$.

2. *Daytime ionosphere of Venus.* Altogether, 13 successful radio-sounding runs of the daytime ionosphere of Venus were performed at sun zenith angles $10° < z_{\odot} \lesssim 87°$. A preliminary analysis of the measurement results has shown that to obtain the altitude profiles $N(h)$ of the electron density it is necessary to take into account the refraction of the radiowaves in the ionosphere of the planet. The procedure used for an approximate solution of the inverse problem of two-frequency radio sounding, assuming spherical symmetry but with allowance for refraction, was proposed and developed by L. N. Samoznaev, who also performed all the subsequente secondary reduction of the measurement results.

Figure 1 shows three $N(h)$ profiles which are most typical of small ($z_{\odot} \approx 14°$) medium ($z_{\odot} \approx 58°$) and large ($z_{\odot} \approx 83°$) zenith angles of the sun. The error in the determination of the profiles in the various sessions was 200–500 cm^{-3}.

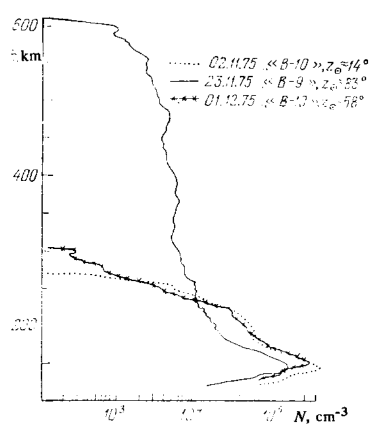

FIG. 1. Distribution of the electron density in the daytime ionosphere of Venus.

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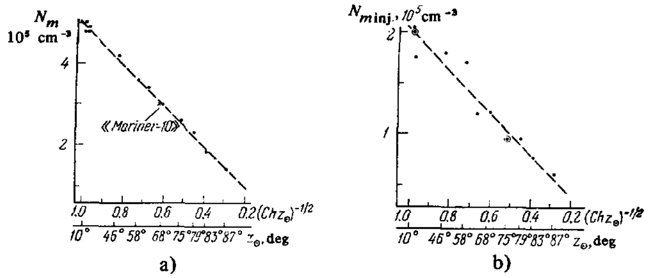

FIG. 2. Dependence of the electron density N_m in the principal (a) and lower (b) maxima of the daytime ionosphere of Venus on the zenith angle $z_\odot$ of the sun.

The region of the principal maximum under different illumination conditions is characterized by maximum values of the electron density $1.4 \cdot 10^5$ cm$^{-3} < N_m \lesssim 5 \cdot 10^5$ cm^{-3}. It follows from the theory of the simple layer[2] that N_m should be proportional to $(\mathrm{Ch}z_\odot)^{-1/2}$, where $\mathrm{Ch}z_\odot$ is the Chapman function. Therefore, to verify the hypothesis that the principal maximum of the ionization in the daytime ionosphere of Venus is produced by a photochemical mechanism, the expected dependence shown in Fig. 2a was plotted. It is seen from this plot that the experimental points for the entire range of zenith angles of the sun fit quite well a straight line in the employed coordinates, thus confirming the indicated hypothesis. It should be noted that in certain runs the height of the principal maximum does not agree with the theory of the simple layer, as can be seen from Fig. 1. The reasons for this discrepancy are not yet clear.

On all 13 profiles in the height range 130–140 km, a lower maximum of the electron density is observed and manifests itself in most cases as an inflection of the $N(h)$ curve (see Fig. 1). The dependence of N_m on $(\mathrm{Ch}z_\odot)^{-1/2}$, shown in Fig. 2b was also plotted for this layer. Despite the fact that for this layer the value of N_m is determined less accurately than for the principal maximum, the experimental points likewise fit the straight line quite well. This is further evidence of the photochemical origin of the layer, whose ionizing agent is apparently the soft x-radiation of the sun.

On the $N(h)$ profiles one can see at $z_\odot < 75°$ a secondary maximum located above the principal maximum (see Fig. 1). With increasing zenith angle, this maximum becomes less and less pronounced, and at $z_\odot \gtrsim 75°$ it takes the form of a break in the profile.

The use of the two-frequency method of radio sounding and a careful analysis of the measurement results on a control section free of the influence of the planetary ionosphere have made it possible to obtain reliable data on the distribution of the electron density above the secondary maximum and in the region of the ionopause. As seen from Fig. 1, at small zenith angles of the sun one observes above the secondary maximum a monotonic and rapid decrease of the electron density all the way to the ionopause, located at a level ~270 km. At $z_\odot \approx 58°$ this region of the monotonic decrease is longer and the ionopause lies at heights ~300 km. At large zenith angles of the sun (> 75°) and at heights above 250–300 km, an extended region of plasma is formed with a concentration on the order of several thousand electrons per unit volume, and with an upper boundary located at heights 500–600 km. An orderly growth of the height h_i of the ionopause is observed in the range $10° \lesssim z_\odot < 83°$, and at $z_\odot \gtrsim 83°$ the value of h_i decreases somewhat. These new data are of undoubted interest when it comes to explain the mechanism of interaction of the ionospheres of nonmagnetic planets with the solar wind. It should be noted that the experimentally obtained dependence does not agree with the theory developed in[3].

Nighttime ionosphere of Venus. Altogether, 22 of radio-sounding runs of the nighttime ionosphere of Venus were performed, of which three were at the sun's zenith angles $90° < z_\odot < 120°$ (transition regime) and the remainder at zentth angles $z_\odot \gtrsim 130°$, corresponding to pure nighttime conditions.[4]

By way of example, Fig. 3 shows three of the most characteristic profiles of the electron density in the nighttime ionosphere of Venus. In the overwhelming majority of the runs, the observed distribution had two maxima (profile 1 on Fig. 3), of which the uppermost was as a rule larger than the lowest. The values of the electron density ranged from $2.9 \cdot 10^3$ to $1.6 \cdot 10^4$ cm^{-3} in the upper maximum, and from $1.8 \cdot 10^3$ to $1.1 \cdot 10^4$ cm^{-3} in the lower one. The average height of the upper maximum was ~137 km, and the distance between maxima was ~ 15 km. The total height range of the nighttime ionosphere of Venus was only 40–60 km, at a level determined by the measurement errors. The same group includes the profile 2 of Fig. 3, a distinguishing feature of which is a very narrow (with respect to height) upper layer with a concentration ~ $1.6 \cdot 10^4$ cm^{-3} at the maximum.

Profiles with one maximum (3 on Fig. 3) have concentrations close to the maximal ones, and their total thickness is also 40–60 km.

The most important feature of all these profiles is the strikingly small height range of the nighttime ionosphere of Venus in general, and the very low values of the half-thicknesses and scales of the heights of each of the layers in particular. Thus, the average value of the height scale, determined for regions above the upper maximum,

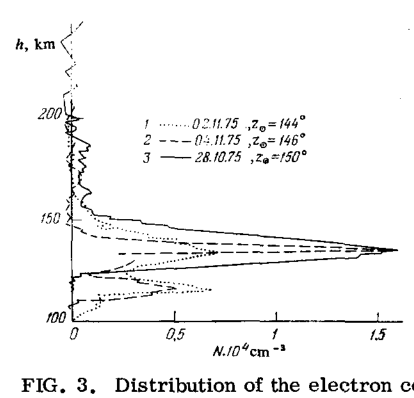

FIG. 3. Distribution of the electron concentration in the nighttime ionosphere of Venus.

is ~ 5 km, and the largest and smallest values are ~ 13 and ~ 1 km, respectively. According to the known mechanisms of formation of ionized regions under the influence of ultraviolet or corpuscular radiation, in the absence of a magnetic field, so low a value of the average scale of heights can be regarded as an indication of very low temperatures,of the upper atmosphere of Venus during the nighttime. Thus, assuming the principal component of the atmosphere to be CO_2, we can estimate the temperature at heights 120–140 km to be ~ 100 °K. This estimate, however, must be verified to see that it does not contradict all the known experimental data and theoretic concepts.

An alternate hypothesis is the assumption that at the heights of both maxima there exist thin localized layers of small impurities whose ionization governs the formation of the nighttime ionosphere of Venus.[5] This hypothesis resolves readily the main difficulty—the explanation of the very existence of two ionization maxima. However, at present there are no experimental data whatever to confirm this assumption.

[1]M. B. Vasil'ev *et al.*, Kosm. Issled. **13**, 48 (1975).

[2]G. S. Ivanov-Kholodnyĭ, and G. M. Nikol'skiĭ, Solntse i ionosfera (The Sun and the Ionosphere), Nauka, 1969.

[3]J. R. Spreiter *et al.*, Planet. Space Sci. **18**, 1281 (1970).

[4]Yu. N. Aleksandrov *et al.*, Kosm. Issled. **14**, 824 (1976).

[5]D. M. Butler *et al.*, J. Geophys. Res. **81**, 4757 (1976).