V. I. Moroz, V. M. Linkin, and D. Oertel. *The results of an infrared experiment on Venera-15 and -16.* From October to December 1983 about 1500 infrared spectra of Venus were transmitted by the Venera-15 and -16 satellites.[1,2] The experiment was carried out as part of the Interkosmos program together with Institutes of the USSR and GDR Academies of Sciences. The apparatus (Fourier spectrometer) was built in GDR and tested in the USSR, and reception and primary data processing were also performed in the USSR. The interpretation of the results is being carried out jointly.

The spectra were recorded in the range from 250 to 1600 cm^{-1} (i.e., from 40 to 6 μm) with a wave number resolution of 5 or 7.5 cm^{-1}. The field of view (about 4°) permitted distinguishing on the planet sections with dimensions of about 60 km (near the pericenter of the orbit). These were the first measurements of the outgoing thermal radiation of Venus with the help of a satellite-borne spectral instrument. They cover the range of latitudes from -66 to 87°.

Samples of the spectra obtained in different parts of the planet are shown in Fig. 1. Their most distinctive feature is the absorption band of CO_2 at 667 cm^{-1} (15 μm). There are actually many bands of carbon dioxide in this region, but absorption at the fundamental frequency ν_2, corresponding to the bending oscillation of the CO_2 molecules, makes the largest contribution. The optical thickness τ at the center of this band reaches a level where the pressure ≈ 0.5 mbar, i.e., a height of about 90 km. The altitude dependence of the temperature from approximately 60 to 90 km was reconstructed from the profile of the 15-μm band (see below). The curves represented in Fig. 1 exhibit a number of other weaker bands of CO_2: the "hot" bands (544, 791, 961, and 1064 cm^{-1}) and the "isotopic" bands, belonging to $^{12}C^{16}O^{18}O$ (1259 and 1366 cm^{-1}). This is the first observation of the complete profile of the 15-μm band in Venus' spectrum.

The lines of a rotational band of H_2O have also been recorded for the first time in Venus' thermal radiation spectrum; they lie in the range 280–475 cm^{-1}. The fundamental ν_3 band of SO_2 contributes to the absorption near 1360 cm^{-1}. This band has also never been achieved previously in addition to the absorption bands of gases, the bands of sulfuric acid can also be identified in the spectra obtained (diffuse details near 500 and 900 cm^{-1}).

Different sections of the spectrum inside the 15-μm band are formed at different heights. The temperature profile of the atmosphere can be reconstructed from each spectrum by solving the inverse problem of radiation transfer. Examples of such a reconstruction are given in Fig. 2. It

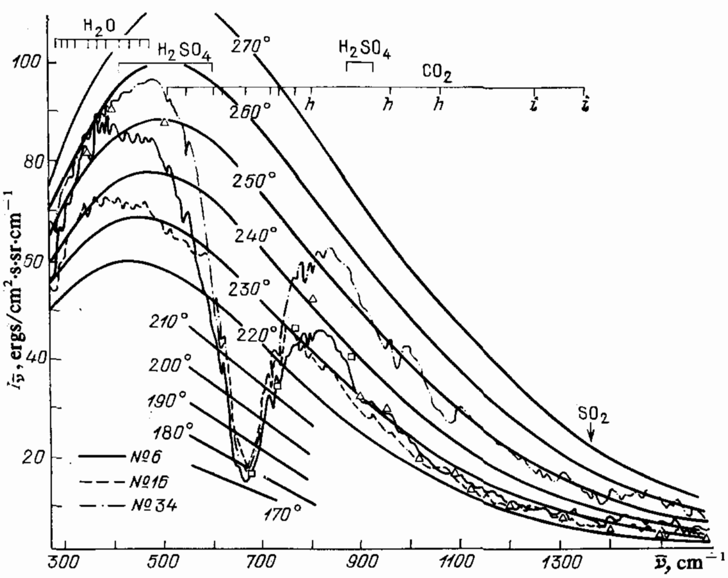

FIG. 1. Typical spectra obtained in a session of measurements on October 14, 1983. No. 6, $\varphi = 48°$ is an example of a spectrum in the first group (latitude less than 60°); No. 16, $\varphi = 67°$ is an example of a spectrum in the second group (latitudes 70–75°, night side); No. 34, $\varphi = 82°$ is an example of a spectrum in the third group ("hot" region, latitudes 77–82° daytime). The positions of the absorption bands of CO_2, H_2O, and SO_2 and of the aerosol (water solution of H_2SO_4) are indicated. The squares are the brightness temperatures, measured in the infrared experiment on the Pioneer-Venera orbiter (orbit 33, $\varphi = 50°$, see Fig. 6 of the paper by Taylor *et al.*[3]). The triangles show the synthetic aerosol emission spectrum, obtained in modeling the spectra in the first group (see text). The letters *h* mark the hot bands of CO_2; *i* marks the bands of the isotropic molecules $^{12}C^{16}O^{18}O$.

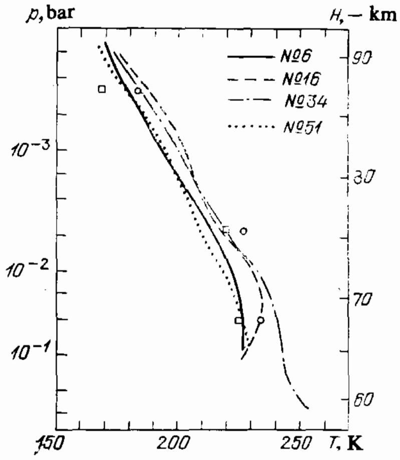

FIG. 2. Vertical profiles of the atmospheric temperature above the clouds, obtained from the spectra No. 6 ($\varphi = 48°$, nighttime), No. 16 ($\varphi = 67°$, nighttime), No. 34 ($\varphi = 82°$, daytime), and No. 51 ($\varphi = 50°$, daytime). The approximate altitudes are given on the right. The squares and circles are the temperatures of the atmosphere determined from the infrared data from the Pioneer-Venera satellite (Taylor *et al.*[3]) at altitudes of 50 and 70°, respectively.

turns out that at altitudes of 70–90 km Venus' atmosphere is systematically warmer at high latitudes than at low latitudes. On the day and night sides of the planet the temperatures practically coincide, while at high latitudes Venus' atmosphere at an altitude of 70–90 km is systematically warmer than at low latitudes.

The spectra obtained in different latitude zones also exhibit systematic differences outside the 15-μm band. These differences are attributable to the different structure of the clouds in these zones. The clouds on Venus cover the entire planet with a continuous layer approximately 20 km thick, but their structure is not the same in different locations on the planet. In the latitude belt $|\varphi| \lesssim 60°$ the upper cloud level is less dense and thicker. The solid line in Fig. 1 shows a typical spectrum of such clouds; it is characterized by much higher brightness temperatures in the regions $280 < \tilde{\nu} < 500$ cm^{-1} than in the region $800 \lesssim \nu \lesssim 1300$ cm^{-1}. The clouds can be approximately described as a medium with a constant particle density of about 100 cm^{-3} below the 72-km level (the upper boundary of the clouds). The spectrum agrees with the assumption that the particles have an average radius of about 1 μm and 75% of their content consists of an aqueous solution of H_2SO_4. At latitudes 70–80° the typical spectrum is much closer to a Planck spectrum (dashed curve in Fig.1). Here the same model must contain lower cloud boundary (65–69 km), and in addition this boundary coincides with the almost isothermal part of the temperature profile. Finally, so-called "hot spots" with a very low upper boundary of about 60 km and a density of 750 cm^{-3} (the spectrum of such a "spot" is shown by the dot-dashed line) are encountered at latitudes near 80°.

Quantitative estimates of the mixture ratio (the content of H_2O and SO_2 was estimated from the "low-latitude" spectra) are as follows:

$$f_{H_2O} = 2{,}5\cdot 10^{-5} \text{ at } 58 \text{ km},$$
$$f_{SO_2} = 6\cdot 10^{-8} \text{ at } 66 \text{ km}.$$

The estimates are given in volume fractions. Measurements of H_2O and SO_2 by other methods are available only for lower (<50 km) and higher (>70 km) altitudes in the atmosphere. The general picture agrees with the model in which the content of both components drops off rapidly with increasing altitude above 50–55 km.

Further analysis of the measurements will yield detailed data on the temperature and pressure fields above 60 km, the thermal-wind field, and the pattern of local-time variations of the content of H_2O and SO_2.

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[2]D. Oertel, J. Nopirakowski, V. I. Moroz, V. M. Linkin, H. Becler-Ross, and D. Spankuch, Wiss. Fortschr. No. 9, 34 (1984).
[3]F. W. Taylor, R. Beer, M. T. Chahin *et al.*, J. Geophys. Res. **85**, 7963 (1980).

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