VISUAL ESTIMATES OF THE COLOR OF THE TWILIGHT SKY FROM OBSERVATIONS ABOARD THE "SOYUZ-5" SPACECRAFT

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Abstract

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Corresponding Member of the USSR Academy of Sciences K. Ya. KONDRATYEV,
A. P. GAL' TSEV, O. I. SMOKTII, E. V. KHRUNOV

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Optical studies of the Earth' s atmosphere carried out during the flight of the "Soyuz-5" spacecraft provided for the simultaneous photographing and spectrophotometry of the twilight aureole, as well as visual observations to determine the vertical evolution of the brightness and color of the twilight sky near the horizon. In accordance with the program, visual observations of the twilight aureole were made on 15 January 1969 (2nd and 6th orbits) and on 16 January 1969 (15th orbit). The geographical coordinates of the "Soyuz-5" spacecraft at the moment the visual observations were made were approximately as follows: 2nd orbit, 30° S and 157.4° E (near the eastern coast of Australia); 6th orbit, 51.69° S and 147.13° E (region of the Auckland Islands); 15th orbit, 4.29° S and 131.66° E (region of the island of New Guinea). The orbital altitude of the "Soyuz-5" spacecraft was $h \simeq 233$ km. The visual observations preceded the experiment on spectrophotometry of the twilight aureole and were carried out when the angle of the Sun' s descent below the horizon was approximately $\delta_{\odot} \simeq 3$—15°.

The synoptic situation in the subsatellite zone was stable: hurricanes, cyclones, etc. were absent. Observations of the altitude evolution of the color and brightness of the twilight aureole were made under conditions of a cloudless atmosphere (2nd orbit), continuous cloud cover (6th orbit), and broken cloud cover (15th orbit). The visual observations of the vertical distribution of the color of the twilight aureole in a cloudless atmosphere may be summarized as follows. The Earth' s limb is seen distinctly as a black line. Near the Earth' s surface the twilight aureole is colored in reddish-orange tones. As the height of the sighted layer increases, the color of the aureole gradually changes to yellow-orange and yellow, adjoining which is a narrow dark-blue band of reduced brightness, situated at approximately a height equal to 1/3 of the visible size of the aureole. Immediately beyond the dark-blue band lies a region colored in blue and light-blue tones. Occupying approximately 2/3 of the visible size of the aureole, this

region at the boundary with open space (black color) is colored in dark-blue and black-violet tones. As the angle of the Sun' s descent below the horizon decreases, the brightness of the aureole increases and the dark-blue band disappears. At the same time the saturation of the color tones of the twilight aureole increases.

In the case of continuous cloud cover, the role of the underlying surface is played by the upper boundary of the clouds. The vertical evolution of the aureole color remains the same as in the case of a cloudless atmosphere. However, in the lower part the aureole is colored in purple-red and dark-pink tones. The upper edge of the cloud layer is diffuse and begins to glow as the angle of the Sun' s descent below the horizon decreases, owing to scattering of sunlight. At the same time the brightness of the aureole in the lower layers noticeably increases. In the case of broken cloud cover, the evolution of color in the vertical direction is the same as indicated above. The gaps in the cloud layer are colored in red tones.

In some essential details the color picture of the twilight halo given above differs from the data of other authors. Thus, for example, according to the descriptions of V. V. Nikolaeva-Tereshkova (^1), the lower part of the halo, colored in red-orange and yellow tones, passes through a broad whitish band into light-blue, dark-blue, and black-violet tones. According to the data of visual observations made by D. McDivitt and E. White from the spacecraft *Gemini 4* (^2), the sequence of coloration of the halo in the vertical direction from the horizon line was as follows: red-orange tones, yellow, light-blue, whitish, then again light-blue and blue, and, finally, whitish (a broad band).

According to the observations of K. P. Feoktistov (^3), the vertical evolution of the color tones of the twilight halo is as follows: from red-orange to yellow, blue, and whitish, then again blue and whitish, and, finally, once more blue and whitish.

Differences in the description of the color of the twilight halo in the vertical direction indicate that: 1) the particular meteorological situation in the terrestrial atmosphere during the flights of the spacecraft *Vostok-6*, *Gemini 4*, *Voskhod*, and *Soyuz-5* was different; in addition, the geometry of sighting the twilight halo and the magnitude of the angle of sunset of the Sun below the horizon also differed; 2) colorimetric data are a sensitive indicator of the features of the vertical structure of the atmosphere. In a separate publication (^4) the authors compared the results of visual observations of the color of the twilight sky with data from quantitative colorimetry based on the processing of twilight spectra, which made it possible to analyze correctly the influence of the structure of the atmosphere on the color picture of the horizon.

It should also be borne in mind that the perception of color by cosmonauts is subjective and depends not only on the specific optical characteristics of their eyes and on such general physiological features of human vision as brightness and color adaptation, etc. The study of these questions, which falls within

the competence of physicians and biologists, is extremely important for the interpretation of colorimetric data obtained from space. It is therefore desirable that such studies be carried out in the very near future by specialists in the appropriate disciplines.

Leningrad State University
named after A. A. Zhdanov

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Note: Figure translations are in progress. See original paper for figures.