Communications

Lunar Tidal Variations of Hydroxyl Emission

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The intensities and rotational temperatures of upper atmospheric hydroxyl emission have regular variations with a period of the moon's age. The values of $\Delta I/I$, $\Delta T_{rot.}/T_{rot.}$ and $\Delta T_{vibr.}/T_{vibr.}$ show variations with the moon's age and have a maximum of 30% in the case of intensity, 6% in the case of rotational temperature and 15% in the case of vibrational temperature for the mean annual lunar variations.

THE PROPERTIES of lunar tides in the upper atmosphere at altitudes of about 80 to 90 km can be revealed from the characteristics of the variations of atmospheric emission of the mesopause region. For this purpose use was made of data about the intensities and rotational temperatures of OH bands obtained from spectral observations at Zvenigorod (near Moscow). Regular patrol measurements were conducted with the aid of spectrographs[1] since 1957. The line of sight was directed northwards at a zenith distance of 60°. Therefore, the geographical coordinates of the atmospheric region under observation at the altitudes of about 90 km were as follows: the latitude 58° N and the longitude 37° E.

In the period of observations the exposure during photography of spectra lasted the whole night. Therefore, the data obtained were compared with the corresponding age of the moon. However, the middle exposure moment did not always correspond to local midnight. To calculate the moon's effective position during the search for possible tidal effects the correction ΔL was introduced into the tabulated values of the moon's age. This correction was determined by the magnitude of the deviation of the moment t_c of the middle exposure from local night t_0, i.e.

$$\Delta L = \frac{29{\cdot}5}{24} (t_0 - t_c) = 1{\cdot}23\ \Delta t$$

In order to search lunar variations, use was made of data on the intensities and rotational temperatures of OH bands (4, 1), (5, 2), (6, 2) and (7, 3) and on vibrational temperature calculated from these bands. All these hydroxyl emission parameters have considerable seasonal variations[2-6]. On the average, rotational and vibrational temperatures are maximum in winter and minimum in summer. The maximum amplitude of $T_{rot.}$ is about 30 to 40° K (ref. 2), and that of $T_{vibr.}$ about 3000° K (Ref. 4, 5). On the average, the intensities of bands are maximum in winter and decrease in equinoctial periods by some 40 to 60% (Ref. 3, 4).

Besides, there is a trend towards systematic change of the intensity and rotational temperatures during the solar cycle[3]. Hence, average seasonal variations and average variations during some years for intensities, rotational and vibrational temperatures were excluded from the available measuring data. The deviations ΔI, $\Delta T_{rot.}$ and $\Delta T_{vibr.}$ obtained from mean monthly values were normalized to corresponding average annual values of I, $T_{rot.}$ and $T_{vibr.}$

To reveal lunar variations the method of superimposed periods was used. For this purpose the values of $\Delta I/I$, $\Delta T_{rot.}/T_{rot.}$ and $\Delta T_{vibr.}/T_{vibr.}$ for all seasons were systematized according to the moon's age and then averaged with a sliding three-day interval.

The existence of lunar variations of hydroxyl emission was detected earlier from scanty data[2]. More numerous data used in this paper made it possible to rule out more exactly the effect of seasonal variations and to reveal more clearcut variations of intensities, rotational and vibrational temperatures with the period of the moon's age (Fig. 1). It is evident from Fig. 1 that the intensities and rotational temperatures change in phase and counterphase with vibrational temperature. As regards the intensity of the OH band (7, 3), the variations are weakly pronounced. The values of $\Delta I/I$, $\Delta T_{rot.}/T_{rot.}$ and $\Delta T_{vibr.}/T_{vibr.}$ show variations with the moon's age and have a maximum of 30% in the csae of intensity, 6% in this case of rotational temperature and 15% in the case of vibrational temperature for the mean annual lunar variations.

The results obtained show considerable influence of lunar tides on the properties of the mesosphere which manifest themselves in the behaviour of hydroxyl emission. The comparison of average relative amplitudes of intensity and of rotational temperature showed that their ratio is about 4-5. Within the limits of errors this value coincides with a similar ratio which follows from calculations for the case of rapid adiabatic oscillations in the atmosphere[7].

Besides, the amplitude of lunar variations of the rotational temperature has the seasonal vari-

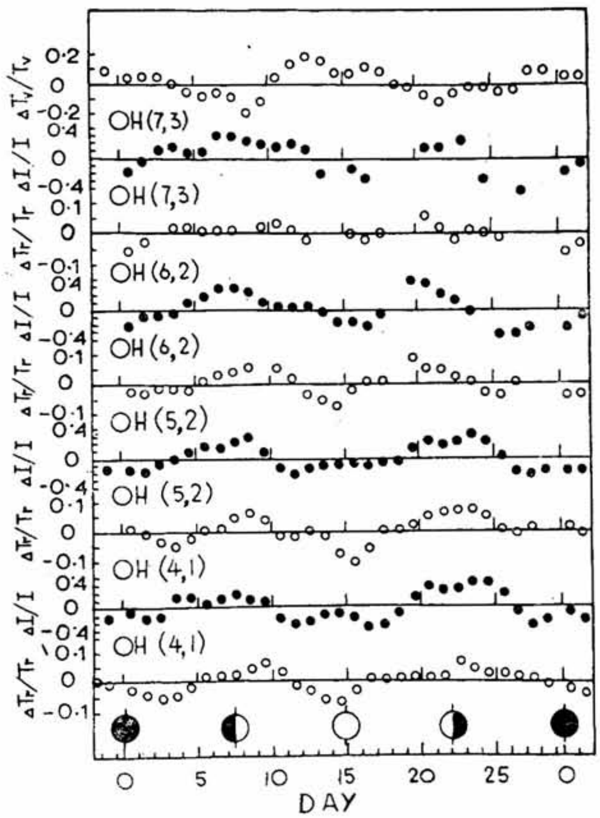

Fig. 1—Variations of intensities, rotational and vibrational temperatures for OH bands (4,1), (5,2), (6,2) and (7,3) with a period of the moon's age according to observations made at Zvenigorod

ations. It is maximum in summer (~20°K) and minimum in winter (~7°K). It is about 12°K in spring and autumn. The ratio between the summer and winter amplitudes is about 3. Making use of these values, theoretical calculations of the amplitude of the lunar tide in the upper atmosphere[8,9] indicate that there are the seasonal variations of the altitude of the hydroxyl emission layer. It would be desirable to make the comparison with the available data of the rocket measurements of the OH altitude. Unfortunately the rocket data are meagre and are related to the spring and autumn periods. Nevertheless, they showed the tendency of lunar-time variations near 90 km level. It is evident that OH altitude measurements by rocket are very essential during winter and summer.

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Relation between Disturbed Variations of Hydroxyl Emission & Radio Wave Absorption in D Region

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The variations of hydroxyl emission and radio wave absorption after geomagnetic storms in middle latitudes are observed to be similar. A correlation between these values is noted.

THE INFLUENCE OF geomagnetic storms on the upper atmospheric conditions manifests itself not only during a storm, but also after it. For instance, in a few days after a storm typical oscillating variations in the intensity and rotational temperatures of hydroxyl emission[1,2] are observed at middle latitudes, as well as variations in some other emissions, such as the atmospheric system of molecular oxygen at 8645 Å, helium at 10830 Å, hydrogen at 6562 Å (Ref. 3,4) and oxygen green emission at 5577 Å (Ref. 5). The duration of such disturbed variations of the emission intensities lasts 3 to 4 weeks, depending on the magnitude of a magnetic storm.

The analysis of the behaviour of upper atmospheric emissions shows that the phenomena observed stem from the transfer of activated masses of air from high latitude regions towards the equator at an average speed of about 10 m/sec. The stored energy of the dissociation of molecular oxygen ensures a considerable enhancement of hydroxyl emission for a long period of time. However, this additional energy release in hydroxyl emission decreases with a decrease of latitude[2,6]. The subsidence time is about 2 days.

However, besides variations in atmospheric emission, the after-effect is revealed in some of its other characteristics, including radio wave absorption. According to some workers[7,8], at stations in middle latitudes 2 or 3 days after a storm a systematic increase of absorption was observed. Although rather