43. OBSERVATIONS OF THE LEONID METEOR SHOWER IN NOVEMBER 1966 IN THE U.S.S.R.

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In connection with the expected passage of the Earth through the densest part of the Leonid meteoric stream in November, 1966, the Commission on Comets and Meteors of the Astronomical Council of the U.S.S.R., and the All-Union Astronomical-Geodetic Society, organized visual, photographic and radar observations of the shower at many points in the Soviet Union.

The exact moment of the maximum was not known previously. According to the ephemeris of A. Simonenko it would occur on November 16, 17^h UT, and according to I. Astapovič's ephemeris on November 17, 10^h UT. Unfortunately, Astapovič's ephemeris was not published in time and was first presented at the Kiev conference, two weeks before the date of the maximum.

As a consequence of this, Simonenko's ephemeris was adopted and it was expected that observations of the Leonid maximum could be made on the evening of November 16 over most of the territory of the Soviet Union.

In general, the visibility of the Leonid shower depends on two independent conditions: (1) night-time, i.e. the Sun must be at least 6° below the horizon; (2) the radiant must be above the horizon. Each condition can be represented on the Earth's surface by a circle, dividing the Earth into three regions of different astronomical significance (Figure 1).

Region I – the radiant is above the horizon during the night-time; optical and radar observations are possible.

Region II – the radiant is above the horizon during the day-time; only radar observations are possible.

Region III – the radiant is below the horizon; neither optical nor radar observations are possible.

At the actual moment of maximum, November 17, 12^h UT, Region I extended over the territory of the West and Central States of the U.S.A., the West and Central parts of Canada, Alaska, and the Pacific Ocean, as well as the North and Northeast areas of the Soviet Union and the Central Arctic (Figure 2).

The first communication about the observations of the meteoric rain was received from the Soviet arctic islands, station 'Izvestija ZIK'. The chief of this station, Ljubuhin, and the hydrologist, Kločkov, observed the shower during 40 min between

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11^h50^m and 12^h30^m UT. An appeal was transmitted by radio to all stations of the Soviet Arctic, and we have received reports from 14 stations. These stations are grouped into three regions: the region of the North Land (Severnaja Zemlja), the region of Čukotka, and the region of the North Geographic Pole. However, this distribution reflects only the meteorological conditions over the area.

The observations from the Soviet stations give the following results:

(a) The moment of maximum was at November 17, $12^h05^m \pm 10^m$ UT.

FIG. 1. *Map of the Western hemisphere of the Earth, showing the observational conditions of the 1966 Leonid meteor shower. 1 – radiant on the horizon, 2 – the Sun on the horizon, 3 – radiant in culmination, 4 – the Sun at 6° below the horizon, I, II, III – see the text, Z – radiant in zenith.*

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(b) The duration of the shower was between 20 and 40 min, the more accurate estimate from station Malyj Tajmyr giving the time interval as 11^h52^m–12^h13^m.

(c) The rate of meteors (without any corrections) was estimated by the observers as 5–10 per second, which means 18000–36000 per hour. If we take into account the

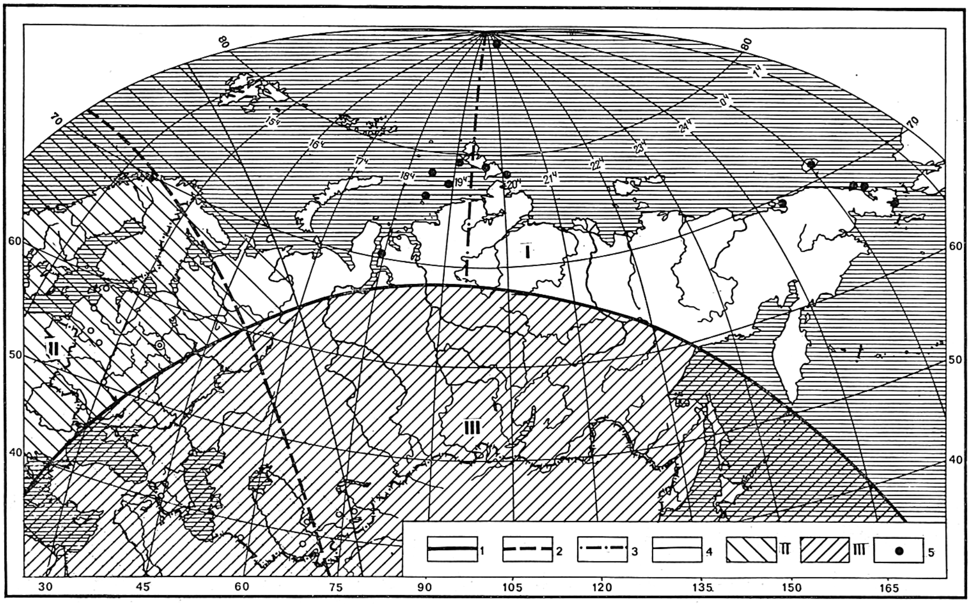

FIG. 2. *Map of the observational conditions in the Soviet Union during the 1966 Leonid shower (November 17, 12ʰ UT). All designations are the same as in Figure 1. The black dots (5) indicate the arctic stations, where the shower has been observed.*

zenith angle of the radiant (82° at the 'Izvestija ZIK' islands), and divide by the cosine of this angle, we obtain a corrected hourly rate of about 130000 meteors per hour. This quantity is in close agreement with one found by American observers (Kitt Peak, Ariz., 40 meteors per second or 140000 per hour).

(d) The meteors were all white, in great part with long-duration trains, and all observers noted the flight of meteors by groups, 5–10 meteors in each group. This indicates a fragmentation of meteoroids before entering the Earth's atmosphere. The white colour is a simple consequence of the high geocentric velocity of the Leonids, about 70 km/sec.

(e) Some bright fireballs with long-duration trains were observed on the following night, November 18, at about 18^h UT. These fireballs were observed near Ašhabad, at Bjurakan, Taškent, Dušanbe, Nalčik and at the arctic station Tadibijaga (in Ob gulf). Figure 3 shows five photographs of such a fireball, taken at three stations near

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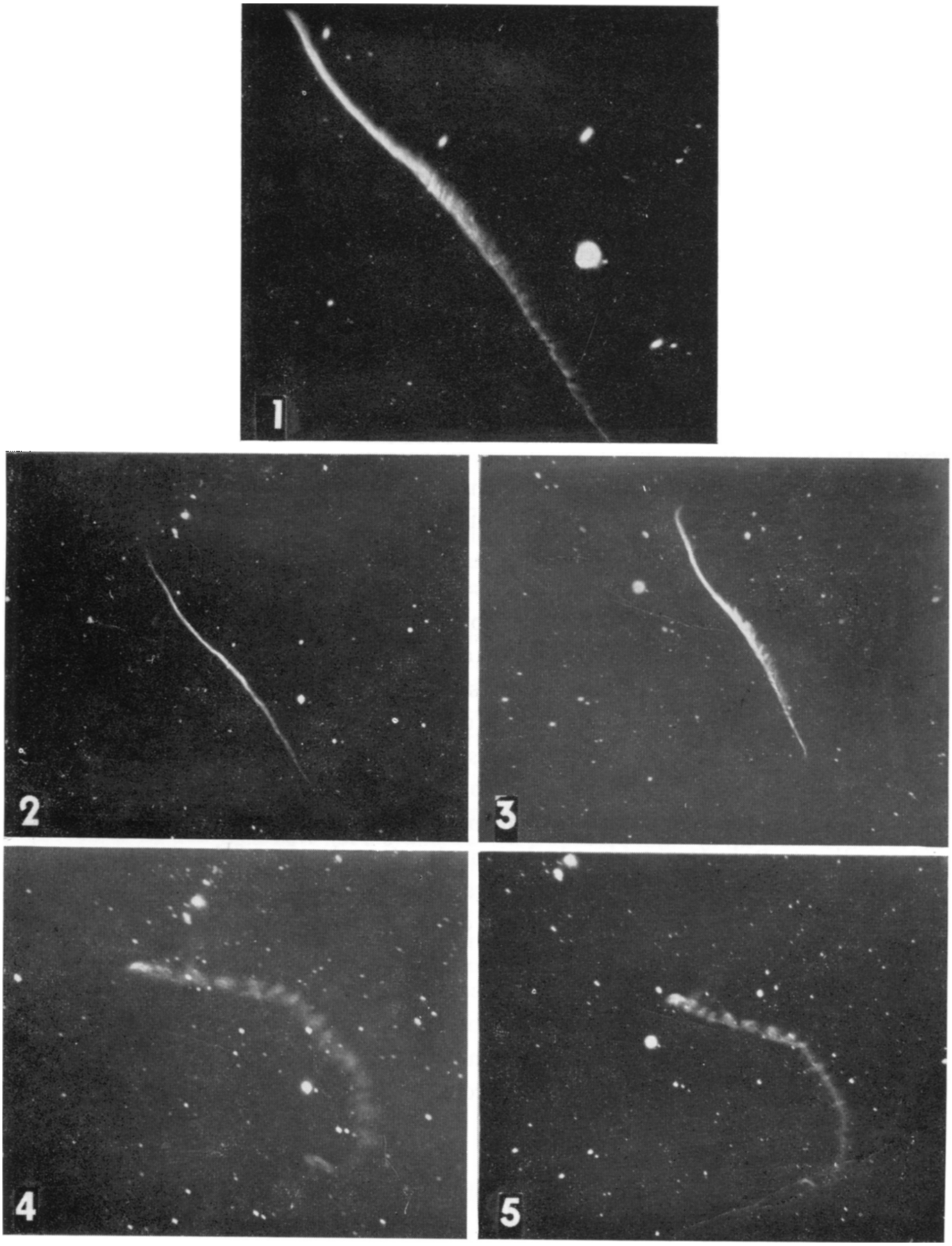

FIG. 3. *A trail of a bright fireball (Leonid) photographed on November 18, 1966 at the Astrophysical Observatory of the Turkmenian Academy of Sciences. Photos 1–3 made 4 sec after the flight, 4–5 after 4 min. 1 – Ašhabad, 2, 4 – Vannovskoe station, 3, 5 – Bekrava station. The bright star is Rigel.*

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Aŝhabad (Turkmenia), namely, in Aŝhabad City, Vannovskoe and Bekrava. Photos 1–3 were obtained 4 sec after the meteor flight, and photos 4–5 some 4 min later. Photo 1 was obtained at Aŝhabad by Nasyrova, 2 and 4 at Vannovskoe by Gulmedov, and 3 and 5 at Bekrava by Erošin.

What can we conclude on the basis of these observations? Firstly, one must note the relatively short duration of the shower. According to Humboldt, the shower of 1799 was visible during 4 hours. In 1832 and 1833 the period of activity was about 6–7 hours. In 1866, according to Greenwich observations, this time interval was 2 hours. Finally, in 1966 it was only 20–40 min (the American observers give only 10 min).

The hourly rate in 1966 was also lower than in 1799 and 1832–33, although higher than in 1866.

What is the cause of these events? One can put forward two explanations. The first, that in 1966 the Earth crossed the meteoric stream not along its diameter but along a chord. The length of this chord was about 90000 km.

The second explanation is that the stream is composed of many meteoric groups of different sizes, and that the Earth in various maximum years crosses different clouds. This point of view will be discussed in a further communication. In this case the diameter of the cloud was about 30000 km. Photographic observations of this shower, using the all-sky cameras of the aurora program, were made at four Soviet arctic stations. The results of these observations cannot be reported at this time.

Visual and radar observations of Leonids were made at many stations in the Soviet Union on the continent. All observations during the night of November 16–17 show a slow increase in the hourly rate of meteors, but it did not exceed 50–60 meteors per hour. Only in Dušanbe the hourly rate before the local dawn (about 1^h UT) increased up to 300 meteors per hour. On November 18 the hourly rate has decreased.

According to R. L. Hotinok's calculations the space density of the stream, observed in part on the night of November 16–17, was $2{\cdot}5 \times 10^{-8}$ km^{-3}, and in the denser part $2{\cdot}5 \times 10^{-5}$ km^{-3}. The distance between two meteors in the stream would be 350 and 35 km respectively.

Now we are faced with the question: could a new meteoric rain be observed in November 1967? Such a possibility is not excluded. According to V. A. Malcev's ephemeris (published in 1932 and confirmed by the observations of the last year) the maximum of the shower would occur on the date: 1967 November 17, 17^h UT.

Note added in proof. The observations of the Leonid shower were organized by the Astronomical-Geodetic Society of the U.S.S.R. in November 1967 at many points of the country (including two Arctic stations). But the shower was poor, the hourly rate of meteors was about 5–8.

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DISCUSSION

Whipple: Congratulations to Dr. Bronšten. One would expect this highly concentrated shower to represent relatively new cometary meteoroids. Thus they should contain a larger fraction of fragile bodies. This should appear as multiplicity and splitting of the meteors, best observed at high-zenith distances of the radiant. Also the beginning heights should be greater than for older Leonids and fragmentation more prevalent. The mass-index effect has already been observed. The effect might even appear in mean meteoroid-density determinations. The 1967 shower should be observed with these possible factors in mind.

Bronšten: During the next apparition of the Leonid shower in 1967, observations must be organized in different latitudes and longitudes, so that the effect of different radiant elevations may be studied.

McCrosky: The Prairie Network observed over 1000 Leonid trails of $M < -5$ in 1965. Poor weather in 1966 limited the yield to about 500. These data remain unreduced because of the difficulty of associating common trails when films contain 10 or 15 individual events. With sufficient justification, we would entertain the idea of reducing this material. Most of these show the typical Leonid terminal flare. Is the s value for this shower influenced by these rather peculiar light curves?

Hemenway: We attempted to collect particles in 1966 during the Leonid shower and were unsuccessful. In 1965 on November 18 we were successful and found a large increase in small particle ($\leqslant 5\mu$ dia.) number densities with altitude. The particles were of low densities and showed evidence of partial entry melting. The altitude ranges sampled were 50–58, 58–68, 68–87, and 87–147 km and the fluxes of particles increased by about 2·5 orders of magnitude with altitude.

Levin: The short durations of bright displays of Draconids and Leonids indicate that the central dense cores of these streams have not a cylindrical but a flattened form. In the cross-section of the stream the lines of equal density are not circular, and it is not sound to analyze the observations on the basis of such an oversimplified model.

Millman: I think that the remarkable agreement between the peak Leonid rates determined by the visual observers in the U.S.S.R. and the U.S.A. respectively gives evidence of the usefulness, even today, of the visual observer, and I make a plea that we continue to supplement instrumental data with visual records.

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