GEMINID METEOR SHOWER: ACTIVITY AND MAGNITUDE DISTRIBUTION

V. PORUBČAN, M. KRESÁKOVÁ, J. ŠTOHL

Astronomical Institute of the Slovak Academy of Sciences, Bratislava, Czechoslovakia

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Abstract: A series of visual observations of the Geminid meteor shower, comprising over 8000 records of meteors during nine revolutions of the shower in 1944—1974 at the Skalnaté Pleso Observatory, is analysed. A mean curve of activity is constructed, and the individual deviations are discussed. In spite of the long time-span covered by observations, no evidence of the predicted regression of the node is found. The magnitude distribution exhibits a definite decrease of its index around the peak of the shower activity. This is in qualitative agreement with the predicted mass separation by the Poynting—Robertson effect, as well as with the radar observations of fainter meteors.

1. Introduction

This paper presents a statistical analysis of the extensive series of visual observations of the Geminid meteor shower obtained at the Skalnaté Pleso Observatory. Motivated by the cooperative Intercosmos programme of investigation of the structure of selected meteor streams, these materials are mainly intended as a base for subsequent linking up with observations by other techniques, pertaining to meteor particles in other mass ranges.

Of the nine shower apparitions analysed, the earlier six cover the late preradar period. The additional three apparitions, spaced by longer time-spans, are from the years when parallel observations by radio techniques are already available. The last observation of 1974 was a part of a broader campaign, using both spacecraft and ground-based optical and radio techniques.

The original observational records have been treated from two points of view. First, it was attempted to obtain a standard curve of activity around the shower maximum by combining observations from different returns, and to trace the individual deviations from this curve. Second, the magnitude distribution of the Geminid meteors was examined, with special regard to its variations along the path traversed by the Earth through the stream.

A common drawback of visual meteor observations is a lack of homogeneity, making an intercomparison of observations from different times and sources very difficult, if not impossible. Therefore, we endeavoured to use a most homogeneous sample extending over three decades, and to compensate the inevitable change of observers by special procedures of tying up the data.

A comparison with the radar records of the Geminids will be published elsewhere.

2. Observational Data and Their Treatment

Visual observations of the Geminids analysed in this paper were obtained at the Skalnaté Pleso Observatory (20°.2 E, 49°.2 N) during nine different returns of this meteor stream from 1944 till 1974. From 1944 till 1949 observations were carried out every year by a standard team of observers, occasionally joined by some additional observers of less experience. Data from the last three apparitions, i.e. 1953, 1958 and 1974, were obtained by larger groups of observers. The method of observations and analysis has been described in detail elsewhere (Kresáková, 1966; Štohl, 1969; Porubčan and Štohl, 1978). A list of all observers who participated in the observations is given in Table 1 together with their abbreviations, total observational time, and numbers of shower and sporadic meteors. The data include a total of 6120 records of the Geminids and 2364 sporadic meteors recorded during 241.4 hours of net observing time.

For the analysis, all observations were divided into approximately 30-minute intervals, in which the observed rates of the Geminids f_i^+ and sporadic meteors f_i^- for individual observers were determined from

Table 1. List of observers

Observer	Abbr.	t	n_+	n_-	c_p								
					1944	1945	1946	1947	1948	1949	1953	1958	1974
Antal M.	An	910	624	143	—	—	—	—	—	—	0.85	0.85	0.85
Antalová A.	Vi	470	236	101	—	—	—	—	—	—	—	0.91	—
Bečvář A.	T	2186	861	304	0.99	1.15	1.20	1.10	1.14	0.89	—	—	—
Dzubák M.	M	979	332	199	0.91	1.08	1.19	—	—	—	—	—	—
Forgáč M.	F	363	70	40	—	—	—	1.00	—	—	—	—	—
Guth V.	G	141	68	21	—	—	—	—	—	—	1.14	—	—
Hajduková M.	Ko	170	91	26	—	—	—	—	—	—	—	0.95	—
Hartmanová M.	H	326	123	56	—	1.52	—	—	—	—	—	—	—
Kiss V.	Ki	149	15	11	1.64	—	—	—	—	—	—	—	—
Kresák Ľ.	K	1755	680	321	—	—	1.03	1.13	—	—	0.63	0.89	—
Kresáková M.	Ka	579	299	104	—	—	—	—	—	—	0.73	1.02	—
Mrkos A.	A	1258	529	159	—	—	0.87	0.91	1.24	1.02	—	—	—
Olejník Š.	O	499	41	58	1.04	1.12	—	—	—	—	—	—	—
Pajdušáková Ľ.	L	2504	939	475	1.00	1.00	1.00	1.00	1.00	1.00	—	1.00	—
Paroubek A.	Pa	189	132	55	—	—	—	—	—	—	0.80	—	—
Podstanická R.	Ps	189	96	53	—	—	—	—	—	—	0.89	—	—
Porubčan V.	Po	300	186	41	—	—	—	—	—	—	—	—	0.89
Svoreň J.	Sv	338	172	27	—	—	—	—	—	—	—	—	0.92
Štohl J.	St	470	246	112	—	—	—	—	—	—	—	0.81	—
Tremko J.	Tr	150	80	11	—	—	—	—	—	—	—	1.18	—
Uhlár J.	U	150	22	14	1.21	—	—	—	—	—	—	—	—
Zvolánková J.	Sl	408	278	33	—	—	—	—	—	—	—	—	0.82
Total		14483	6120	2364									

$$f_i = 30 \frac{n_i}{t_i}. \tag{1}$$

The rates f were then corrected so as to relate to a standard observer and to standard observing conditions.

As the standard observer L. Pajdušáková (L) was chosen, who has the longest series of observations. She participated in 7 of the 9 years of Geminid observations. The personal coefficients (c_p) of individual observers with respect to the observer L, computed for each year separately, are given in Table 1. The values for 1944 to 1949 are taken from a comprehensive analysis of the sporadic meteor rates (Štohl, 1969). Personal coefficients for 1958 are based on these observations of the standard observer L. For years 1953 and 1974, when L did not participate, c_p are referred to L indirectly using the rates of observer An, who took part in all three latter observed returns of the Geminids.

For the reduction of the observed rates to standard observing conditions, f_i were corrected for cloudiness using the factor c_l defined by Guth (1941). They were also converted to the zenithal rates by the factor $c_z = \cos^{-1} z$, where z is the angular distance of the apparent radiant from the zenith. Factor c_z includes a correction for the zenith attraction, and takes into account the motion of the radiant with varying solar longitude $\lambda_\odot$. For the position and daily motion of the radiant the values derived from photographic observations of the Geminids by Kresák and Porubčan (1970) for equinox 1950.0 were adopted, i.e.

$$\begin{aligned} \alpha &= 112.^\circ 3 + 0.97(\lambda_\odot - 261^\circ), \\ \delta &= \ \ 32.^\circ 4 - 0.08(\lambda_\odot - 261^\circ). \end{aligned} \tag{2}$$

No correction for the change of the limiting magnitude was taken into account, since 1. in the earlier years of observation the limiting magnitude was not noted and 2. its change is practically negligible for the altitude of Skalnaté Pleso (1783 m), with a good air transparency on each cloudless night.

Taking into account the coefficients mentioned, the observed half-hourly rates of the Geminids f_+ and sporadic meteors f_- for individual observers are

$$\begin{aligned} f_+ &= f_i^+ c_p c_l c_z, \\ f_- &= f_i^- c_p c_l, \end{aligned} \tag{3}$$

where c_p are personal coefficients, c_l and c_z the correction factors for the cloudiness and for reduction to the zenithal rates, respectively.

The observations from different years, arranged according to their solar longitudes reduced to equinox 1950.0, are summarized in Table 2. The table lists the dates, solar longitudes for the middle of the observational intervals, observers (their abbreviations), percentage of cloudiness (Cl), observed numbers of shower and sporadic meteors (n_+ and n_-), and their reduced rates f_+ and f_- (Eq.

Table 2

Day	Sun	Time (UT)	Obs.	Cl	n_+	n_-	f_+	f_-
			December 1944					
4	252.62	18:51—19:28	M	5	—	6	—	4.6
4	252.62	18:51—19:28	O	15	1	6	2.0	5.8
4	252.62	18:51—19:28	Ki	15	—	5	—	7.7
5	253.62	18:44—19:14	L	10	—	10	—	11.0
5	253.62	18:47—19:14	M	5	—	8	—	8.5
5	253.62	18:50—19:14	T	5	1	9	2.6	11.7
5	253.64	19:14—19:44	L	10	1	8	2.0	8.8
5	253.64	19:14—19:44	M	5	—	9	—	8.6
5	253.64	19:14—19:44	T	5	—	5	—	5.1
5	253.66	19:44—20:13	L	10	1	8	1.9	9.1
5	253.66	19:44—20:13	M	5	1	9	1.5	8.8
5	253.66	19:44—20:13	T	—	2	5	3.4	5.1
9	257.89	23:39—00:11	L	30	5	9	6.9	11.7
9	257.90	23:45—00:11	M	35	3	3	4.8	4.6
11	259.71	18:37—19:07	U	—	1	3	2.7	3.6
11	259.72	18:45—19:07	L	—	3	4	8.8	5.5
11	259.74	19:07—19:37	U	—	4	8	9.2	9.7
11	259.74	19:07—19:37	L	—	4	7	7.6	7.0
11	259.76	19:37—20:07	U	15	2	—	4.7	—
11	259.76	19:37—20:07	L	10	2	4	3.7	4.4
11	259.83	21:17—21:47	U	5	10	2	16.1	2.5
11	259.83	21:25—21:47	L	—	11	3	18.8	4.1
11	259.83	21:17—21:47	T	—	10	5	12.6	5.0
11	259.85	21:47—22:17	U	25	5	1	9.6	1.6
11	259.85	21:47—22:17	L	10	10	3	13.1	3.3
11	259.85	21:47—22:17	T	15	11	3	15.1	3.5
13	260.99	00:49—01:19	M	30	18	10	23.8	12.6
13	260.99	00:49—01:19	T	45	22	5	39.1	8.5
13	261.73	18:14—18:30	M	—	7	3	30.8	5.1
13	261.73	18:22—18:30	T	—	3	2	28.1	7.4
13	261.73	18:09—18:30	O	—	12	3	46.6	4.5
13	261.74	18:30—19:00	M	—	14	5	28.9	4.6
13	261.74	18:30—19:00	T	—	20	4	44.9	4.0
13	261.74	18:30—19:00	O	—	12	—	28.4	—
13	261.76	19:00—19:30	M	—	19	2	33.9	1.8
13	261.76	19:00—19:30	T	—	21	6	40.9	5.9
13	261.76	19:00—19:12	O	—	7	1	37.2	2.6
13	261.77	19:12—19:30	Ki	—	5	1	21.2	2.3
13	261.79	19:30—20:00	M	25	12	5	24.8	6.0
13	261.79	19:30—20:00	T	30	11	2	26.3	2.8
13	261.79	19:30—20:00	Ki	65	9	1	64.9	4.1
15	263.81	19:18—19:48	L	15	2	5	4.2	5.8
15	163.81	19:18—19:48	M	40	—	1	—	1.5
15	263.81	19:18—19:48	O	40	—	5	—	8.3
15	263.81	19:22—19:48	T	25	1	4	2.4	5.9
15	163.83	19:48—20:15	L	30	—	1	—	1.6
15	263.83	19:48—20:15	M	65	1	2	4.6	5.6
15	263.83	19:48—20:15	O	65	—	1	—	2.9
15	263.83	19:48—20:15	T	55	1	2	3.8	4.6
16	264.77	17:58—18:28	T	—	—	5	—	5.0
16	264.77	17:58—18:28	Ki	—	—	3	—	4.9
16	264.78	18:00—18:28	L	—	—	6	—	6.4

16	164.78	18:00—18:28	O	—	1	1	3.0	1.1
16	164.80	18:28—18:58	T	—	1	2	2.3	2.0
16	264.80	18:28—18:58	Ki	—	1	1	3.8	1.6
16	264.80	18:28—18:58	L	—	—	2	—	2.0
16	164.80	18:28—18:58	O	—	—	2	—	2.1
16	264.94	21:54—22:24	T	—	5	4	5.8	4.0
16	264.94	21:54—22:24	L	—	2	5	2.4	5.0
16	264.94	21:54—22:24	O	—	—	7	—	7.3
16	264.96	22:24—22:54	T	—	3	3	3.4	3.0
16	264.96	22:24—22:54	L	—	1	2	1.1	2.0
16	264.96	22:24—22:54	O	—	2	2	2.4	2.1
16	264.98	22:54—23:24	T	—	2	6	2.2	5.9
16	264.98	22:54—23:24	L	—	4	6	4.4	6.0
16	264.98	22:54—23:24	O	—	1	5	1.1	5.2
17	265.91	20:50—21:00	T	30	3	1	17.2	4.2
17	265.91	20:50—21:00	M	10	1	4	4.2	12.1
17	265.91	20:50—21:00	O	—	—	1	—	3.1
17	265.92	21:00—21:30	T	10	—	2	—	2.2
17	265.92	21:00—21:30	M	5	—	5	—	4.7
17	265.92	21:00—21:30	O	—	1	7	1.4	7.3
17	265.94	21:30—22:00	T	—	2	2	2.5	2.0
17	265.94	21:30—22:00	M	—	—	2	—	1.8
17	265.94	21:30—22:00	O	—	—	3	—	3.1
17	265.96	22:00—22:34	T	—	2	2	2.1	1.8
17	265.96	22:00—22:34	M	—	1	3	0.9	2.4
17	265.96	22:00—22:34	O	—	3	4	3.2	3.6
19	267.97	21:15—21:45	T	—	—	2	—	2.0
19	267.97	21:15—21:45	M	—	1	3	1.2	2.7
19	267.99	21:45—22:15	T	—	—	3	—	3.0
19	267.99	21:45—22:15	M	—	—	6	—	5.4

December 1945

3	251.36	19:15—19:45	T	—	—	4	—	4.6
3	251.36	19:15—19:45	L	—	—	5	—	5.0
3	251.36	19:15—19:45	O	—	—	4	—	4.5
3	251.38	19:45—20:15	T	—	1	4	1.8	4.6
3	251.38	19:45—20:15	L	—	1	3	1.6	3.0
3	251.38	19:45—20:15	O	—	1	2	1.8	2.2
3	251.40	20:15—20:45	T	5	—	1	—	1.2
3	251.40	20:15—20:45	L	—	—	7	—	7.0
3	251.40	20:15—20:45	O	—	—	4	—	4.5
7	254.64	00:45—01:15	T	—	2	2	2.4	2.3
7	254.64	00:45—01:15	L	—	1	7	1.0	7.0
7	254.64	00:45—01:15	H	—	2	7	3.2	10.6
7	254.66	01:15—01:45	T	30	1	4	1.7	6.4
7	254.66	01:15—01:45	L	20	2	2	2.6	2.5
7	254.66	01:15—01:45	H	45	2	3	5.5	7.9
7	254.68	01:45—02:15	T	10	1	13	1.4	16.4
7	254.68	01:45—02:15	L	20	1	6	1.3	7.4
7	254.68	01:45—02:15	H	5	—	5	—	7.9
7	254.70	02:15—02:48	T	—	2	7	2.3	7.4
7	254.70	02:15—02:48	L	—	2	6	2.0	5.5
7	254.70	02:15—02:48	H	—	1	6	1.5	8.4
13	260.72	00:23—01:00	T	—	38	9	36.9	8.4
13	260.72	00:23—01:00	L	—	43	5	36.3	4.1
13	260.72	00:23—01:00	M	—	26	11	23.8	9.6
13	260.74	01:00—01:15	M	—	11	7	24.8	15.1
13	260.75	01:00—01:28	T	—	22	10	28.4	12.3
13	260.75	01:00—01:28	L	—	21	9	23.6	9.6
13	260.77	01:28—02:00	T	—	37	5	42.4	5.4

Table 2 (Continued)

13	260.77	01:28—02:00	L	—	33	6	32.9	5.6
13	260.77	01:28—02:00	M	—	41	14	44.2	14.1
13	260.77	01:28—02:00	H	—	28	5	42.4	7.1
13	260.79	02:00—02:32	T	—	24	8	28.3	8.6
13	260.79	02:00—02:32	L	—	32	10	32.8	9.4
13	260.79	02:00—02:32	M	—	25	11	27.6	11.1
13	260.79	02:00—02:32	H	—	16	8	24.9	11.4
13	260.81	02:32—03:00	T	—	37	10	51.5	12.3
13	260.81	02:32—03:00	L	—	31	10	37.6	10.7
13	260.81	02:32—03:00	M	—	38	7	49.8	8.1
13	260.81	02:32—03:00	H	—	20	5	36.8	8.2
13	260.85	03:00—04:32	T	—	88	27	41.3	10.1
13	260.85	03:00—04:32	L	—	89	26	36.3	8.5
13	260.85	03:00—04:32	M	—	87	32	38.3	11.2
13	260.85	03:00—04:32	H	—	46	14	28.6	7.0
13	260.89	04:32—04:47	T	—	18	6	59.1	13.8
13	260.89	04:32—04:55	L	—	27	9	50.7	11.7
13	260.89	04:32—04:55	M	—	23	10	46.7	14.0
13	260.89	04:32—04:55	H	—	8	3	22.8	5.9
			December 1946					
4	251.41	02:33—03:03	L	—	4	11	4.5	11.0
4	251.41	02:33—03:03	A	—	3	9	3.0	7.8
4	251.43	03:03—03:33	L	—	—	7	—	7.0
4	251.43	03:03—03:33	A	—	—	10	—	8.7
11	259.40	23:34—00:00	L	—	3	2	3.7	2.3
11	259.40	23:34—00:00	A	—	6	5	6.4	5.0
11	259.40	23:34—00:00	K	—	1	2	1.2	2.4
12	259.42	00:00—00:30	L	—	5	1	5.2	1.0
12	259.42	00:00—00:30	A	—	4	3	3.7	2.6
12	259.42	00:02—00:30	K	—	1	3	1.1	3.3
12	259.44	00:30—01:00	L	—	1	2	1.0	2.0
12	259.44	00:30—01:00	A	—	3	2	2.7	1.7
12	259.44	00:30—01:00	K	—	4	1	4.3	1.0
12	259.47	01:00—01:34	L	—	4	1	3.7	0.9
12	259.47	01:00—01:34	A	—	7	—	5.7	—
12	259.47	01:00—01:34	K	—	2	2	2.0	1.9
13	261.20	18:05—18:30	L	—	9	6	28.7	7.2
13	261.21	18:15—18:30	K	—	8	2	42.4	4.1
13	261.22	18:30—19:02	L	—	14	1	29.6	0.9
13	261.22	18:30—19:02	K	—	15	2	32.7	2.0
13	261.27	19:42—20:00	L	—	18	—	50.9	—
13	261.27	19:42—20:00	K	—	12	4	34.9	6.9
13	261.27	19:42—20:00	A	—	11	1	27.1	1.5
13	261.27	19:42—20:00	T	—	8	1	27.1	2.0
13	261.29	20:00—20:39	L	—	35	2	41.3	1.5
13	261.29	20:00—20:30	K	—	20	5	32.1	5.2
13	261.29	20:00—20:30	T	—	24	2	44.9	2.4
13	261.30	20:19—20:38	A	—	19	1	39.2	1.4
13	261.31	20:30—20:52	K	—	16	3	32.3	4.2
13	261.31	20:30—21:00	T	—	8	1	13.7	1.2
13	261.31	20:48—21:00	A	—	5	1	15.1	2.2
13	261.33	21:05—21:30	L	—	12	1	18.9	1.2
13	261.33	21:00—21:30	A	—	18	2	20.6	1.7
13	261.33	21:00—21:30	T	—	14	1	22.1	1.2
13	261.35	21:30—22:00	L	—	26	2	32.1	2.0
13	261.35	21:30—22:00	A	—	29	1	31.1	0.9
13	261.35	21:30—22:00	T	—	15	3	22.2	3.6
13	261.36	22:00—22:09	L	—	5	1	19.9	3.3
13	261.37	22:09—22:30	K	—	15	3	25.6	3.7

13	261.37	22:00—22:30	A	—	19	4	19.3	3.5
13	261.37	22:00—22:17	T	—	10	1	25.1	2.2
13	261.39	22:30—22:46	K	—	15	2	32.8	3.9
13	261.39	22:30—22:46	A	—	18	1	33.2	1.7
13	261.39	22:35—22:46	T	—	9	—	33.2	—
13	261.44	23:30—00:00	K	—	15	4	16.4	4.1
13	261.44	23:30—00:00	A	—	16	3	14.8	2.6
13	261.44	23:45—00:00	T	—	9	—	22.8	—
14	261.46	00:00—00:30	K	—	22	4	23.7	4.1
14	261.46	00:00—00:30	A	—	23	3	21.0	2.6
14	261.46	00:00—00:30	T	—	16	4	20.0	4.8
14	261.48	00:30—01:00	K	—	21	3	22.6	3.1
14	261.48	00:30—01:00	A	—	25	2	22.7	1.7
14	261.48	00:30—01:00	T	—	11	1	13.8	1.2
14	261.52	01:25—02:00	K	—	23	4	21.5	3.5
14	261.52	01:25—02:00	A	—	41	2	32.5	1.5
14	261.52	01:25—02:00	T	—	16	3	17.5	3.1
14	261.54	02:00—02:30	K	—	20	4	22.5	4.1
14	261.54	02:00—02:20	A	—	17	5	24.1	6.5
14	261.54	02:00—02:17	T	—	3	2	6.8	4.2
14	261.55	02:20—02:30	L	—	7	—	23.2	—
14	261.56	02:30—03:00	L	—	14	8	15.8	8.0
14	261.56	02:30—03:00	K	—	15	2	17.5	2.1
14	262.30	19:59—20:30	K	—	6	6	9.4	6.0
14	262.32	20:30—21:00	K	—	9	6	13.2	6.2
14	262.35	21:00—21:32	K	—	3	1	3.8	0.9
14	262.35	21:00—21:32	A	—	8	1	8.6	0.8
14	262.41	22:33—23:00	K	—	4	3	5.2	3.4
14	262.41	22:30—23:00	T	—	3	7	4.1	8.4
14	262.43	23:00—23:30	K	—	5	6	5.6	6.2
14	262.43	23:01—23:30	A	—	13	3	12.7	2.7
14	262.43	23:00—23:30	T	—	8	2	10.4	2.4
14	262.43	23:01—23:30	L	—	6	2	6.7	2.1
14	262.45	23:30—00:00	K	—	4	3	4.3	3.1
14	262.45	23:30—00:00	T	—	3	4	3.8	4.8
14	262.45	23:30—00:00	L	—	3	—	3.2	—
15	262.47	00:00—00:12	K	—	2	1	5.4	2.6
15	262.47	00:00—00:12	T	—	1	—	3.1	—
15	262.47	00:00—00:12	L	—	—	1	—	2.5
15	263.34	20:26—21:00	T	—	1	3	1.6	3.1
15	263.34	20:26—21:00	L	—	1	3	1.3	2.6
15	263.34	20:26—21:00	A	—	—	7	—	5.4
15	263.34	20:26—21:00	K	—	—	4	—	3.6
15	263.34	20:26—21:00	M	—	—	4	—	4.2
16	264.34	19:57—20:30	A	—	—	6	—	5.2
16	264.34	19:57—20:30	K	—	—	1	—	0.9
16	264.34	19:57—20:30	M	—	—	2	—	2.1
16	264.36	20:30—20:57	A	—	3	1	4.2	1.0
16	264.36	20:30—20:57	K	—	—	9	—	10.3
16	264.36	20:30—20:57	M	—	3	5	5.7	6.7
17	265.34	19:30—20:00	M	—	—	5	—	6.0
17	265.34	19:30—20:00	K	—	—	3	—	3.1
17	265.36	20:00—20:30	M	—	—	1	—	1.2
17	265.51	23:47—00:00	M	—	—	1	—	2.7
17	265.51	23:47—00:00	K	—	—	1	—	2.4
18	265.53	00:00—00:30	M	—	—	2	—	2.4
18	265.53	00:00—00:30	K	—	—	8	—	8.2
18	265.54	00:30—00:47	M	—	—	1	—	2.1
18	265.54	00:30—00:47	K	—	—	4	—	7.3

			December 1947					
12	260.05	20:50—21:30	L	—	15	13	15.0	9.8
12	260.05	20:50—21:30	K	—	14	8	15.8	6.8
12	260.05	20:50—21:30	F	—	14	8	14.0	6.0
12	260.05	20:56—21:30	T	—	14	5	17.9	4.8
12	260.07	21:30—22:00	L	—	16	5	19.7	5.0
12	260.07	21:30—22:00	K	—	10	3	13.9	3.4
12	260.07	21:30—22:00	F	—	4	5	4.9	5.0
12	260.07	21:30—22:00	T	—	8	2	10.9	2.2
12	260.09	22:00—22:30	L	—	10	4	11.7	4.0
12	260.09	22:00—22:30	K	—	10	6	13.2	6.8
12	260.09	22:00—22:30	F	—	3	3	3.5	3.0
12	260.09	22:00—22:30	T	—	12	4	15.4	4.4
12	260.11	22:30—23:00	L	—	12	7	13.4	7.0
12	260.11	22:30—23:00	K	—	11	3	13.9	3.4
12	260.11	22:30—23:00	F	—	14	4	15.7	4.0
12	260.11	22:30—23:00	T	—	8	7	9.9	7.7
12	260.13	23:00—23:16	T	—	8	3	18.0	6.2
12	260.14	23:00—23:30	L	—	8	9	8.7	9.0
12	260.14	23:00—23:30	K	—	14	6	17.2	6.8
12	260.14	23:00—23:30	F	—	10	2	10.2	2.0
12	260.16	23:26—00:00	T	—	7	11	7.3	10.7
12	260.16	23:30—00:00	L	—	14	12	14.8	12.0
12	260.16	23:30—00:00	K	—	10	12	12.0	13.6
12	260.16	23:30—00:00	F	—	10	4	10.6	4.0
13	260.18	00:00—00:30	L	—	14	15	14.6	15.0
13	260.18	00:00—00:30	K	—	15	13	17.7	14.7
13	260.18	00:00—00:30	F	—	11	1	11.5	1.0
13	260.18	00:00—00:30	T	—	21	7	24.2	7.7
13	260.20	00:30—00:50	K	—	8	3	14.1	5.1
13	260.20	00:30—00:50	F	—	4	1	6.3	1.5
13	260.20	00:30—00:50	T	—	13	—	22.3	—
13	260.24	01:42—02:00	L	—	15	4	26.7	6.7
13	260.24	01:35—02:00	K	—	19	6	27.5	8.1
13	260.26	02:00—02:30	L	—	17	6	18.5	6.0
13	260.26	02:00—02:30	K	—	24	5	29.6	5.6
13	260.28	02:30—03:00	L	—	20	6	22.6	6.0
13	260.28	02:30—03:00	K	—	19	5	24.3	5.6
13	260.30	03:00—03:30	L	—	15	7	17.7	7.0
13	260.30	03:00—03:30	K	—	21	8	28.0	9.0
17	265.10	19:57—20:30	A	—	2	3	2.6	2.5
17	265.10	19:57—20:30	F	—	—	4	—	3.6
17	265.12	20:30—20:57	A	—	—	4	—	4.0
17	265.12	20:30—20:57	F	—	—	1	—	1.1
18	266.14	20:40—21:00	A	—	1	3	1.9	4.1
18	266.14	20:40—21:00	F	—	—	3	—	4.5
18	266.14	20:40—21:00	K	—	—	3	—	5.1
18	266.16	21:00—21:30	A	—	—	5	—	4.6
18	266.16	21:00—21:30	F	—	—	3	—	3.0
18	266.16	21:00—21:30	K	—	—	3	—	3.4
18	266.17	21:30—21:43	A	—	—	2	—	4.2
18	266.17	21:30—21:43	F	—	—	1	—	2.3
18	266.17	21:30—21:43	K	—	—	3	—	7.8
			December 1948					
9	256.89	00:35—01:00	A	—	4	9	6.2	13.4
9	256.91	01:00—01:35	A	—	1	9	1.1	9.5
10	257.95	01:45—02:00	L	—	1	7	2.1	14.0
10	257.97	02:00—02:30	L	—	5	11	5.4	11.0

10	257.99	02:30—02:45	L	—	1	4	2.2	8.0
12	260.01	02:10—02:30	A	—	11	4	22.4	7.4
12	260.02	02:30—03:00	A	—	17	10	23.8	12.4
12	260.04	03:00—03:10	A	—	2	2	8.7	7.4
13	261.74	19:05—19:30	T	—	4	1	10.6	1.4
13	261.74	19:05—19:30	A	—	8	—	23.2	—
13	261.74	19:05—19:30	L	—	5	1	11.7	1.2
13	261.76	19:30—20:00	T	—	6	—	11.9	—
13	261.76	19:30—20:00	A	—	7	—	15.0	—
13	261.76	19:30—20:00	L	—	3	1	5.2	1.0
13	261.78	20:00—20:30	T	—	7	2	12.4	2.3
13	261.78	20:00—20:30	A	—	9	1	17.4	1.2
13	261.78	20:00—20:30	L	—	9	—	14.0	—
13	261.80	20:30—20:40	T	—	1	—	5.0	—
13	261.80	20:30—21:05	A	—	3	1	4.5	1.1
13	261.80	20:30—21:05	L	—	5	—	6.1	—
			December 1949					
12	260.52	20:42—21:00	T	—	14	—	29.0	—
12	260.52	20:42—21:00	A	—	12	3	28.6	5.1
12	260.54	21:00—21:30	T	—	15	6	17.5	5.3
12	260.54	21:00—21:30	A	—	17	4	22.8	4.1
12	260.56	21:30—22:00	T	—	15	3	16.5	2.7
12	260.56	21:30—21:53	A	—	11	10	18.2	13.3
12	260.57	21:53—22:00	L	—	4	3	20.7	12.9
12	260.58	22:00—22:23	T	—	10	5	13.6	5.8
12	260.58	22:00—22:23	L	—	18	4	27.6	5.2
13	261.54	20:33—21:00	T	—	14	1	19.7	1.0
13	261.54	20:33—21:00	A	—	16	1	25.7	1.1
13	261.56	21:00—21:30	T	—	20	1	23.4	0.9
13	261.56	21:00—21:30	A	—	32	4	42.9	4.1
13	261.58	21:30—22:00	T	—	26	5	28.6	4.4
13	261.58	21:30—21:57	A	—	34	3	47.7	3.4
13	261.60	22:00—22:30	T	—	22	2	22.9	1.8
13	261.60	22:00—22:30	L	—	30	7	35.1	7.0
13	261.62	22:30—23:00	T	—	32	3	32.0	2.7
13	261.62	22:40—23:00	A	—	17	—	29.0	—
13	261.62	22:30—22:40	L	—	9	2	30.6	6.0
13	261.64	23:00—23:33	T	—	22	1	19.3	0.8
13	261.64	23:00—23:33	A	—	27	3	27.1	2.8
14	262.52	19:40—20:00	T	—	5	1	11.4	1.3
14	262.52	19:40—20:00	A	—	4	2	10.4	3.1
14	262.53	20:00—20:32	T	—	6	5	7.7	4.2
14	262.53	20:00—20:32	A	—	6	3	8.9	2.9
			December 1953					
13	261.63	23:12—23:30	An	—	13	2	19.9	2.8
13	261.63	23:12—23:30	Ps	—	12	9	19.2	13.4
13	261.63	23:12—23:30	Pa	—	14	4	20.2	5.4
13	261.63	23:12—23:30	Ka	—	22	6	28.8	7.3
13	261.64	23:30—00:00	An	—	36	8	32.5	6.8
13	261.64	23:30—00:00	Ps	—	19	13	17.9	11.6
13	261.64	23:30—00:00	Pa	—	32	10	27.1	8.0
13	261.64	23:30—23:56	Ka	—	23	7	20.6	5.9
14	261.66	00:00—00:14	An	—	14	10	26.8	18.2
14	261.66	00:00—00:27	Ps	—	15	5	15.5	5.0
14	261.66	00:00—00:27	Pa	—	23	8	21.4	7.1
14	261.66	00:00—00:27	G	—	20	5	26.6	6.4
14	261.67	00:12—00:27	K	—	8	8	10.5	10.1
14	261.74	01:51—02:20	An	—	15	8	14.3	7.1

14	261.74	01:51—02:20	Ps	—	20	8	19.9	7.4
14	261.74	01:51—02:20	Pa	—	15	11	13.4	9.1
14	261.74	01:51—02:20	G	—	18	5	22.9	5.9
14	261.74	01:51—02:20	K	—	21	12	14.8	7.8
14	261.78	02:40—03:05	An	—	28	6	32.6	6.1
14	261.78	02:40—03:05	Ps	—	22	8	26.8	8.5
14	261.78	02:40—03:05	Pa	—	32	5	35.0	4.8
14	261.78	02:40—03:05	Ka	—	33	3	33.0	2.6
14	261.78	02:40—03:05	G	—	16	2	25.0	2.7
15	262.69	00:12—00:30	G	—	5	4	9.9	7.6
15	262.69	00:12—00:30	Ps	—	5	4	7.7	6.0
15	262.69	00:12—00:30	Pa	—	7	6	9.8	8.0
15	262.69	00:12—00:30	Ka	—	6	4	7.7	4.9
15	262.70	00:30—01:00	G	—	6	4	7.2	4.6
15	262.70	00:30—01:00	Ps	—	2	3	1.9	2.7
15	262.70	00:30—01:00	Pa	—	8	7	6.6	5.6
15	262.70	00:30—01:00	Ka	—	12	7	9.1	5.1
15	262.72	01:00—01:12	G	—	3	1	8.9	2.8
15	262.72	01:00—01:12	Ps	—	1	3	2.3	6.7
15	262.72	01:00—01:12	Pa	—	1	4	2.1	8.0
15	262.72	01:00—01:12	Ka	—	2	1	3.8	1.8
			December 1958					
12	260.09	17:40—18:00	St	—	2	2	7.6	2.4
12	260.09	17:40—18:00	An	—	—	1	—	1.3
12	260.09	17:40—18:00	Vi	5	2	4	9.0	3.8
12	260.09	17:40—18:00	L	—	3	1	14.1	1.5
12	260.09	17:40—18:00	Ko	—	1	2	4.5	2.8
12	260.11	18:00—18:30	St	—	5	7	10.8	5.7
12	260.11	18:00—18:30	Vi	10	2	6	5.4	6.0
12	260.11	18:00—18:30	Ka	—	5	6	13.6	6.1
12	260.11	18:00—18:30	L	—	3	5	8.0	5.0
12	260.11	18:00—18:30	K	—	3	2	7.1	1.8
12	260.13	18:30—19:00	An	—	2	4	3.8	3.4
12	260.13	18:30—19:00	Vi	15	3	2	7.1	2.1
12	260.13	18:30—19:00	Ka	—	1	6	2.3	6.1
12	260.13	18:30—19:00	Tr	10	4	2	11.7	2.6
12	260.13	18:30—19:00	K	—	3	7	6.1	6.2
12	260.15	19:00—19:30	St	—	8	3	12.6	2.4
12	260.15	19:00—19:30	An	—	11	2	18.3	1.7
12	260.15	19:00—19:30	Ka	—	7	2	14.0	2.0
12	260.15	19:00—19:30	L	—	6	4	11.7	4.0
12	260.15	19:00—19:30	K	—	7	6	12.2	5.3
12	260.17	19:30—20:00	St	—	7	3	9.8	2.4
12	260.17	19:30—20:00	An	—	11	2	16.2	1.7
12	260.17	19:30—20:00	Vi	—	5	7	7.8	6.3
12	260.17	19:30—20:00	Ko	—	4	5	6.6	4.8
12	260.17	19:30—20:00	L	—	6	6	10.4	6.0
12	260.19	20:00—20:30	St	—	11	3	13.9	2.4
12	260.19	20:00—20:30	Vi	—	6	2	8.5	1.8
12	260.19	20:00—20:30	Ka	—	7	2	11.1	2.0
12	260.19	20:00—20:30	L	—	7	2	10.9	2.0
12	260.19	20:00—20:30	K	—	9	2	12.5	1.8
12	260.21	20:30—21:00	An	—	15	1	18.1	0.8
12	260.21	20:30—21:00	Vi	—	15	5	19.4	4.6
12	260.21	20:30—21:00	Ka	—	7	6	10.1	6.1
12	260.21	20:30—21:00	Tr	—	19	3	31.9	3.5
12	260.21	20:30—21:00	K	—	13	2	16.4	1.8
12	260.23	21:00—21:30	St	—	13	3	13.9	2.4
12	260.23	21:00—21:30	An	—	24	3	26.8	2.6
12	260.23	21:00—21:30	Ka	—	11	3	14.7	3.1

Table 2 (Continued)

12	260.23	21:00—21:30	L	—	12	6	15.8	6.0
12	260.23	21:00—21:30	K	—	11	4	12.8	3.6
12	260.26	21:30—22:00	St	—	7	6	7.0	4.9
12	260.26	21:30—22:00	An	—	16	2	16.7	1.7
12	260.26	21:30—22:00	Vi	—	14	8	15.7	7.3
12	260.26	21:30—22:00	L	—	7	6	8.6	6.0
12	260.26	21:30—22:00	Ko	—	14	2	16.3	1.9
12	260.28	22:00—22:30	St	—	22	11	20.8	8.9
12	260.28	22:00—22:30	Vi	—	20	10	21.2	9.1
12	260.28	22:00—22:30	Ka	—	16	6	19.1	6.1
12	260.28	22:00—22:30	L	—	19	12	22.2	12.0
12	260.28	22:00—22:30	K	—	16	6	16.6	5.3
12	260.30	22:30—23:00	An	—	23	5	21.8	4.2
12	260.30	22:30—23:00	Vi	—	20	4	20.4	3.6
12	260.30	22:30—23:00	Ka	—	21	4	24.0	4.1
12	260.30	22:30—23:00	Tr	—	19	1	25.1	1.2
12	260.30	22:30—23:00	K	—	16	11	15.9	9.8
12	260.32	23:00—23:30	St	—	27	11	23.7	8.9
12	260.32	23:00—23:30	An	—	22	8	20.2	6.8
12	260.32	23:00—23:30	Ka	—	19	6	21.0	6.1
12	260.32	23:00—23:30	L	—	17	12	18.4	12.0
12	260.32	23:00—23:30	K	—	22	10	21.2	8.9
12	260.34	23:30—00:00	St	—	25	10	21.5	8.1
12	260.34	23:30—00:00	An	—	28	6	25.2	5.1
12	260.34	23:30—00:00	Vi	—	25	10	24.1	9.1
12	260.34	23:30—00:00	Ko	—	29	7	29.2	6.6
12	260.34	23:30—00:00	L	—	20	10	21.2	10.0
13	260.36	00:00—00:30	St	—	23	12	19.5	9.7
13	260.36	00:00—00:30	Vi	—	14	8	13.3	7.3
13	260.36	00:00—00:30	Ka	—	18	8	19.2	8.2
13	260.36	00:00—00:30	L	—	16	11	16.7	11.0
13	260.36	00:00—00:30	K	—	21	12	19.6	10.7
13	260.38	00:30—01:00	An	—	34	8	30.1	6.8
13	260.38	00:30—01:00	Vi	—	26	4	24.7	3.6
13	260.38	00:30—01:00	Ka	—	22	14	23.4	14.3
13	260.38	00:30—01:00	Tr	—	27	3	33.2	3.5
13	260.38	00:30—01:00	K	—	22	13	20.4	11.6
13	260.40	01:00—01:30	St	—	29	7	24.6	5.7
13	260.40	01:00—01:30	An	—	19	7	16.9	6.0
13	260.40	01:00—01:30	Ka	—	16	4	17.1	4.1
13	260.40	01:00—01:30	L	—	13	6	13.6	6.0
13	260.40	01:00—01:30	K	—	21	9	19.6	8.0
13	260.42	01:30—02:00	St	—	19	7	16.4	5.7
13	260.42	01:30—02:00	An	—	22	4	19.9	3.4
13	260.42	01:30—02:00	Vi	—	19	5	18.4	4.6
13	260.42	01:30—02:00	L	—	22	3	23.4	3.0
13	260.42	01:30—02:00	Ko	—	18	6	18.2	5.7
13	260.45	02:00—02:30	St	—	17	14	15.1	11.3
13	260.45	02:00—02:30	Vi	—	21	9	20.8	8.2
13	260.45	02:00—02:30	L	—	14	5	15.3	5.0
13	260.45	02:00—02:30	Ka	5	25	5	29.3	5.3
13	260.45	02:00—02:30	K	—	22	8	21.4	7.1
13	260.47	02:30—03:00	An	—	25	7	24.1	6.0
13	260.47	02:30—03:00	Vi	—	28	10	28.8	9.1
13	260.47	02:30—03:00	Ka	—	22	1	25.4	1.0
13	260.47	02:30—03:00	Tr	—	11	2	14.6	2.4
13	260.47	02:30—03:00	K	—	17	9	17.1	8.0
13	260.49	03:00—03:30	St	15	12	7	13.1	6.6
13	260.49	03:00—03:30	An	35	20	6	29.8	7.6
13	260.49	03:00—03:30	Ka	45	4	3	8.3	5.3
13	260.49	03:00—03:30	L	15	15	6	20.6	7.0
13	260.49	03:00—03:30	K	15	15	7	18.3	7.2

Table 2 (Continued)

13	260.51	03:30—04:00	St	35	19	6	28.5	7.2
13	260.51	03:30—04:00	An	45	14	6	25.6	9.0
13	260.51	03:30—04:00	Vi	20	16	7	22.4	7.8
13	260.51	03:30—04:00	L	35	17	7	31.5	10.4
13	260.51	03:30—04:00	Ko	30	25	4	41.3	5.3

(3)). Table 2 may serve as a catalogue of observations; however, remarks to some of the observations are requirable.

In a part of the observations of 1945, namely on December 13 after midnight, records of the times of appearance of meteors in some intervals are missing. The largest gap in the time-record (3:00—4:32 UT) is 92 minutes. In 1946, December 13/14 and 14/15, i.e. shortly after the maximum of activity of the Geminids, the observations were disturbed by the moonshine. Therefore, the reduced rates on these dates are apparently somewhat underestimated. A correction for this effect can be based on the comparison of the magnitude distributions of meteors on these nights, and those, from other returns of the Geminids, made at similar solar longitudes. On December 14, 1953 there is a 20-minute interval (2:20—2:40 UT) of a higher rate, which is not listed in Table 2 because abbreviations of the observers are missing. This observation is only included in the total rates of Table 4. The observations in 1958, obtained during a single night, represent the most homogeneous uninterrupted watch of a constantly large group of observers extending over 10 hours. The observations from 1974 which are published elsewhere (Porubčan and Štohl, 1978), are not represented in Table 2.

A short summary of the observations from different years is given in Table 3. For each year, the table lists total numbers of observers, the nights on which the observations were carried out, the numbers of records of the Geminids and of sporadic meteors. The last column gives total numbers of meteors recorded.

Table 3

Year	Observers	Nights	Shower meteors	Sporadic meteors	All meteors
1944	6	10	322	326	648
1945	5	3	929	379	1308
1946	5	7	875	286	1161
1947	5	3	495	271	766
1948	3	4	109	63	172
1949	3	3	438	82	520
1953	6	2	529	211	740
1958	8	1	1555	608	2163
1974	4	2	868	138	1006
Total	—	35	6120	2364	8484

3. Activity of the Geminids

The course of activity of the Geminids, based on the visual observations reduced to a standard observer and observing conditions, is presented in Table 4. The table contains the dates, the solar longitudes for the mid-points of the observational intervals (Sun), the numbers of observers participating in these intervals (O), the zenithal hourly rates of the Geminids (F_+) and of the sporadic background meteors (F_-) together with the respective natural uncertainties ε_+ and ε_- defined as $\pm\frac{F_+}{\sqrt{n_+}}$ and $\pm\frac{F_-}{\sqrt{n_-}}$, where n_+ and n_- indicate the numbers of the shower and sporadic records, respectively. The table also contains the mean magnitudes ($\bar{m}$) and the effective mean magnitudes ($\bar{m}^*$) of the shower and sporadic meteors which will be referred to in detail later. The observations with cloudiness exceeding the limit of 40 per cent, are omitted, as the corrections become excessive and poorly determined under such conditions.

The observed hourly rates for each year around the maximum of activity of the Geminids (solar longitude from 259° to 263°) obtained from Eq. (3) are plotted in Fig. 1. Individual years are represented by different markings. In some cases, the observations from a given year yield a few data points only, and it is essentially impossible to construct the frequency curve for each year, separately. Therefore, all observations have been put together to construct a common frequency curve, in which the peculiarities of individual years appear as local deviations. As it can be seen from Fig. 1, the observations are spread rather uniformly throughout the main period of the activity, there

Table 4

Sun	Day	Time (UT)	t	O	F_+	ε_+	F_-	ε_-	$\bar{m}_+$	$\bar{m}_+^*$	n_+	$\bar{m}_-$	$\bar{m}_-^*$	n_-
251.37	3.12.45	19:15—20:15	60	3	1.7	1.0	8.0	1.8	2.00	2.00	3	3.08	3.18	22
251.40	3.12.45	20:15—20:45	30	3	—	—	8.5	2.4	—	—	—	2.67	2.67	12
251.42	4.12.46	02:33—03:33	60	2	3.8	1.4	17.2	2.8	3.43	3.43	7	3.03	3.03	37
252.62	4.12.44	18:51—19:28	37	3	1.3	1.3	12.1	2.9	3.00	3.00	1	2.88	2.88	17
253.63	5.12.44	18:44—19:44	60	3	1.5	1.1	17.6	2.5	4.00	4.00	2	2.98	2.98	49
253.66	5.12.44	19:44—20:13	29	3	4.5	2.3	15.3	3.3	4.00	4.00	4	2.73	2.73	22
254.65	7.12.45	00:45—01:45	60	3	4.4	1.5	11.5	2.4	0.30	1.00	10	3.56	3.56	25
254.69	7.12.45	01:45—02:48	63	3	2.8	1.1	17.7	2.7	2.29	2.29	7	3.07	3.07	43
256.90	9.12.48	00:35—01:35	60	1	7.3	3.3	22.9	4.8	2.40	2.40	5	3.11	3.11	18
257.89	9.12.44	23:39—00:11	32	2	11.7	4.1	16.3	4.7	1.75	2.00	8	2.83	2.83	12
257.97	10.12.48	01:45—02:45	60	1	6.5	2.5	22.0	4.7	3.14	3.14	7	3.27	3.32	22
259.40	11.12.46	23:34—00:00	26	3	7.5	2.4	6.5	2.2	3.30	3.30	10	2.00	2.00	9
259.43	12.12.46	00:00—01:00	60	3	6.0	1.6	3.9	1.1	2.17	2.45	18	3.25	3.25	12
259.47	12.12.46	01:00—01:34	34	3	7.6	2.1	1.9	1.1	3.15	3.15	13	3.00	3.00	3
259.71	11.12.44	18:37—19:07	30	2	11.5	5.8	9.1	3.4	2.50	2.50	4	2.86	2.86	7
259.75	11.12.44	19:07—20:07	60	2	12.6	3.6	10.6	2.4	2.83	2.83	12	3.58	3.58	19
259.84	11.12.44	21:17—22:17	60	3	28.4	3.8	6.7	1.7	2.72	2.79	57	3.29	3.29	17
260.03	12.12.48	02:10—03:10	60	1	36.3	6.7	18.1	4.6	3.53	3.53	30	3.38	3.38	16
260.05	12.12.47	20:50—21:30	40	4	31.4	4.1	13.7	2.3	2.09	2.30	57	3.94	3.94	34
260.08	12.12.47	21:30—22:30	60	4	23.3	2.8	8.4	1.5	2.93	3.01	73	3.59	3.59	32
260.09	12.12.58	17:40—18:00	20	5	14.1	5.0	4.7	1.5	2.38	2.38	8	3.00	3.00	10
260.12	12.12.47	22:30—23:30	60	4	26.8	3.0	11.5	1.8	2.92	3.10	84	3.63	3.63	41
260.12	12.12.58	18:00—19:00	60	7	15.2	2.9	9.0	1.4	2.74	2.74	31	3.33	3.33	47
260.16	12.12.47	23:30—00:00	30	4	22.4	3.5	20.2	3.2	3.27	3.27	41	3.67	3.69	39
260.16	12.12.58	19:00—20:00	60	7	23.9	2.8	7.3	1.2	2.45	2.57	72	3.63	3.63	40
260.18	13.12.47	00:00—00:50	50	4	31.6	3.4	10.0	1.5	2.75	2.80	79	3.85	3.85	39
260.20	12.12.58	20:00—21:00	60	7	30.6	3.0	5.4	1.1	2.98	2.98	109	2.07	2.96	28
260.24	12.12.58	21:00—22:00	60	7	29.7	2.6	7.9	1.2	3.19	3.19	127	3.65	3.65	43
260.25	13.12.47	01:35—02:30	55	2	51.2	5.9	13.2	2.9	3.20	3.23	71	3.95	3.95	21
260.29	13.12.47	02:30—03:30	60	2	46.3	5.3	13.8	2.6	3.12	3.14	73	2.81	2.81	26
260.29	12.12.58	22:00—23:00	60	7	41.4	3.0	12.9	1.6	3.02	3.02	190	3.54	3.54	69
260.33	12.12.58	23:00—00:00	60	7	45.1	3.0	16.3	1.7	3.08	3.08	230	3.39	3.39	87
260.37	13.12.58	00:00—01:00	60	7	44.0	2.9	17.3	1.8	3.00	3.05	221	3.20	3.20	93
260.41	13.12.58	01:00—02:00	60	7	37.6	2.7	10.4	1.3	3.03	3.08	196	3.55	3.55	58
260.46	13.12.58	02:00—03:00	60	7	42.4	3.0	12.7	1.5	3.14	3.14	202	3.17	3.17	70
260.50	13.12.58	03:00—04:00	60	6	51.4	4.3	14.8	2.1	2.84	2.84	156	2.97	2.97	59
260.53	12.12.49	20:42—21:30	48	2	49.0	6.4	7.2	2.0	2.95	2.97	58	2.38	2.38	13
260.57	12.12.49	21:30—22:23	53	3	38.6	5.1	16.0	3.2	2.71	2.74	58	3.20	3.20	25
260.72	13.12.45	00:23—01:00	37	3	64.7	6.2	14.7	2.9	3.08	3.10	107	3.48	3.48	25
260.76	13.12.45	01:00—02:00	60	4	68.2	4.9	19.8	2.7	3.05	3.06	193	2.86	2.99	56
260.80	13.12.45	02:00—03:00	60	4	72.3	4.8	20.0	2.4	3.22	3.22	218	3.23	3.23	69
260.85	13.12.45	03:00—04:32	92	4	72.2	4.1	18.4	1.8	2.94	2.94	307	3.02	3.02	99
260.89	13.12.45	04:32—04:55	23	4	89.6	10.3	22.7	4.2	3.36	3.36	76	2.75	3.29	28
260.99	13.12.44	00:49—01:19	30	1	47.6	11.2	25.2	8.0	2.74	2.84	38	3.40	3.40	15
261.17	13.12.74	21:26—22:26	60	4	45.2	3.5	4.2	0.9	2.52	2.53	167	2.32	2.45	19
261.21	13.12.46	18:05—19:02	57	2	66.7	9.9	7.1	2.1	3.20	3.22	46	3.36	3.36	11
261.26	13.12.74	23:38—00:38	60	3	62.7	4.3	5.5	1.2	2.76	2.76	210	2.25	2.25	22
261.27	13.12.46	19:42—20:00	18	4	70.0	10.0	5.2	2.1	3.06	3.06	48	3.00	3.00	6
261.30	13.12.46	20:00—21:00	60	4	62.5	5.5	5.2	1.3	2.80	2.84	127	3.00	3.00	15
261.34	13.12.46	21:00—22:00	60	3	49.0	4.6	3.5	1.1	2.33	2.39	114	3.50	3.50	10
261.36	14.12.74	02:17—02:35	18	3	64.4	8.3	5.8	2.3	2.74	2.76	60	2.67	2.67	6
261.38	13.12.46	22:00—22:46	46	4	54.0	5.7	5.2	1.5	2.37	2.57	91	2.50	2.50	12
261.43	14.12.74	03:42—04:42	60	4	59.9	4.2	11.2	1.6	2.49	2.50	208	2.52	2.52	51
261.44	13.12.46	23:30—00:00	30	3	36.0	5.7	4.5	1.7	3.10	3.10	40	3.57	3.57	7
261.47	14.12.46	00:00—01:00	60	3	41.3	3.8	5.8	1.4	2.93	2.95	118	3.06	3.06	17
261.52	14.12.46	01:25—02:00	35	3	47.7	5.3	5.4	1.8	2.45	2.64	80	3.67	3.67	9
261.55	14.12.46	02:00—03:00	60	4	36.6	4.2	8.3	1.8	2.62	2.67	76	2.95	2.95	21
261.55	13.12.49	20:33—21:30	57	2	55.8	6.2	3.6	1.4	2.62	2.70	82	3.29	3.29	7
261.59	13.12.49	21:30—22:30	60	3	67.2	6.4	8.3	2.0	2.76	2.79	106	3.53	3.53	17
261.63	13.12.49	22:30—23:33	63	3	55.2	5.3	4.9	1.6	2.49	2.64	104	2.67	2.89	9

Sun	Day	Time (UT)	t	O	F_+	ε_+	F_-	ε_-	$\bar{m}_+$	$\bar{m}_+^*$	n_+	$\bar{m}_-$	$\bar{m}_-^*$	n_-
261.64	13.12.53	23:12—00:00	48	4	46.6	3.6	15.3	2.0	2.70	2.73	168	3.16	3.16	57
261.66	14.12.53	00:00—00:27	27	5	40.3	4.5	18.7	3.1	2.42	2.42	77	3.36	3.36	36
261.74	13.12.44	18:09—19:00	51	3	69.2	8.3	8.5	2.0	2.75	2.84	68	2.59	2.59	17
261.75	13.12.48	19:05—20:00	55	3	25.9	4.5	2.4	1.7	0.79	1.15	33	3.00	3.00	3
261.75	14.12.53	01:51—02:20	29	5	34.1	3.6	14.9	2.2	2.34	2.46	89	3.07	3.07	43
261.77	14.12.53	02:20—03:05	45	5	61.0	5.1	9.9	1.9	2.60	2.62	122	3.46	3.46	24
261.78	13.12.44	19:00—20:00	60	4	61.4	6.7	7.1	1.7	3.07	3.11	84	3.89	3.89	18
261.79	13.12.48	20:00—21:05	65	3	19.8	3.4	1.5	0.8	0.88	1.24	34	2.50	2.50	4
262.12	14.12.74	20:08—20:38	30	2	37.1	7.4	3.7	1.8	2.48	2.52	25	3.63	3.63	4
262.23	14.12.74	22:34—23:34	60	4	26.4	2.8	5.8	1.2	2.83	2.84	92	3.07	3.07	23
262.30	14.12.46	19:59—20:30	31	1	18.8	7.6	12.0	4.9	2.50	2.50	6	3.33	3.33	6
262.33	15.12.74	01:08—01:38	30	2	24.3	5.1	9.0	3.0	2.63	2.63	24	2.72	2.72	9
262.34	14.12.46	20:30—21:32	62	2	17.1	3.8	5.3	1.8	1.25	2.55	20	2.75	2.75	8
262.42	14.12.46	22:33—23:30	57	4	14.9	2.3	8.4	1.7	2.74	2.87	39	3.00	3.00	23
262.46	14.12.46	23:30—00:12	42	3	6.6	1.8	4.3	1.4	2.69	2.69	13	3.11	3.22	9
262.53	14.12.49	19:40—20:32	52	2	19.2	4.2	5.8	1.7	2.67	2.67	21	3.27	3.27	11
262.70	15.12.53	00:12—01:12	60	4	12.8	1.7	10.6	1.6	2.86	2.86	58	3.56	3.56	48
263.34	15.12.46	20:26—21:00	34	5	1.2	0.8	7.6	1.6	4.00	4.00	2	3.76	3.76	21
263.82	15.12.44	19:18—20:15	57	2	4.4	2.0	8.9	1.9	3.00	3.00	5	4.05	4.05	21
264.35	16.12.46	19:57—20:57	60	3	3.3	1.3	8.7	1.8	4.17	4.17	6	3.96	3.96	24
264.78	16.12.44	17:58—18:58	60	4	2.3	1.3	6.3	1.3	4.00	4.00	3	3.23	3.23	22
264.95	16.12.44	21:54—22:54	60	3	5.0	1.4	7.8	1.6	3.62	3.62	13	2.61	2.61	23
264.98	16.12.44	22:54—23:24	30	3	5.1	1.9	11.4	2.7	2.71	2.71	7	3.76	3.76	17
265.11	17.12.47	19:57—20:57	60	2	1.3	0.9	5.6	1.6	2.50	2.50	2	3.92	3.92	12
265.35	17.12.46	19:30—20:30	60	2	—	—	6.9	2.3	—	—	0	3.63	3.63	16
265.53	17.12.46	23:47—00:47	60		—	—	8.4	2.0	—	—	0	3.81	3.81	26
265.92	17.12.44	20:50—21:30	40	3	7.6	3.4	11.2	2.5	3.40	3.40	5	3.50	3.50	20
265.95	17.12.44	21:30—22:34	64	3	2.9	1.0	4.9	1.2	3.63	3.63	8	3.50	3.50	16
266.16	18.12.47	20:40—21:43	63	3	0.4	0.4	8.7	1.7	4.00	4.00	1	3.62	3.62	26
267.98	19.12.47	21:15—22:15	60	2	0.6	0.6	6.6	1.8	4.00	4.00	1	3.07	3.07	14

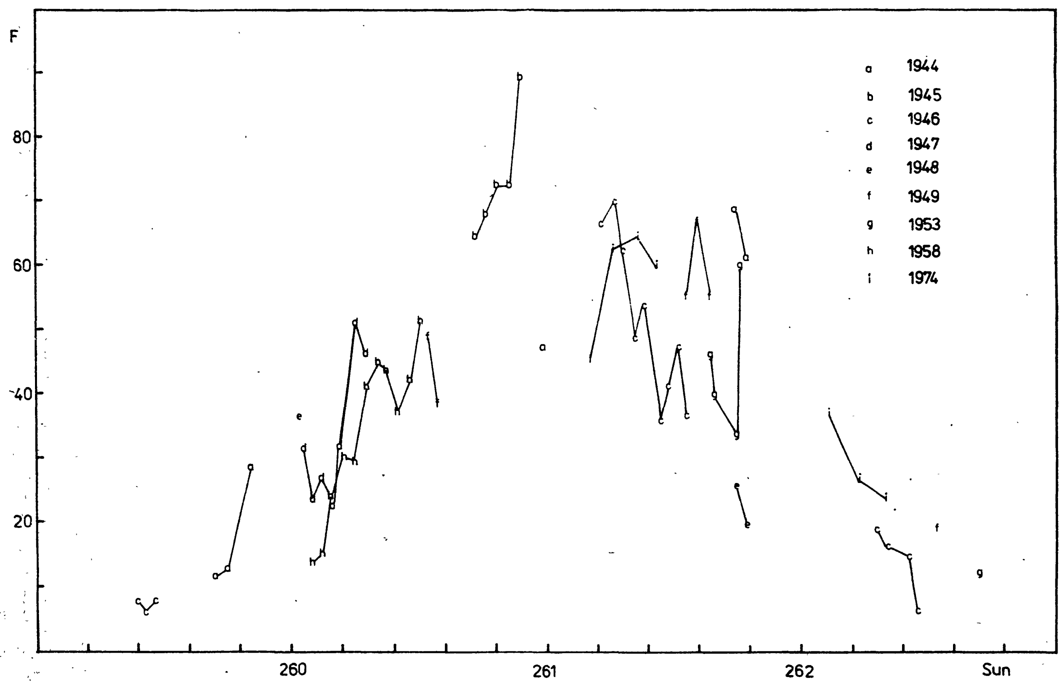

Fig. 1. The reduced hourly rates of the Geminid meteors, F, plotted against the solar longitude at the time of observation. Individual years are distinguished by different markings, and the data from individual nights are connected by straight lines.

is only a small gap around the solar longitude of 262°. At the maximum itself, there is one observation from 1944 ($\lambda_\odot = 260\overset{\circ}{.}99$) of relatively low rate, which is due to one observer only, and therefore has a low weight (high ε_+). The ascending branch of the activity of the Geminids is very well defined, by consistent observations from different returns, with a relatively low spread. The rates on the descending branch show a larger spread, both among individual years and intervals. The two data points from 1948 very probably refer to observations carried out under poor observing conditions, though this fact is not stated explicitly in the original records. A strong argument is that the low meteor rate is accompanied by an unusually high mean brightness (see Table 4). Another deviation is due to the observations of 1946, which from $\lambda_\odot = 261\overset{\circ}{.}3$ onwards were carried out with interfering moonshine.

The highest hourly rate of the Geminids, up to 90 meteors, was observed in 1945 at $\lambda_\odot = 260\overset{\circ}{.}9$. The smoothed hourly rates of all observations included in Fig. 1, both for shower and sporadic meteors, are plotted in Fig. 2. The activity of the Geminids (upper full line) appears to be nearly symmetrical with respect to $\lambda_\odot = 261°$. The smoothed rates of the sporadic background meteors are presented by line with full circles, below. At the maximum of the Geminids, close to $\lambda_\odot = 261°$, there is one observation from 1944 by one observer only (mentioned above). This observer has the highest rate of sporadic meteors of all observations (25.2 meteors per hour) and at the same time his rate of shower meteors is low, apparently due to a wrong classification of the shower membership. After discarding this observation, the course of activity near the maximum becomes much more uniform (dashed line).

There appear several, not particularly pronounced, secondary maxima on the general curve of the Geminids, which may refer to random fluctuations in the distribution of particles within the stream. Some of these maxima are present in more than one return. The enhancement at $\lambda_\odot = 260\overset{\circ}{.}3$, born out by the observations from 1958 and 1947, is independently confirmed by observations made by another group of observers on Mount Lomnický Štít (close to Skalnaté Pleso Observatory), during the same period in 1958 (Grygar et al., 1962). In some years, the sudden increase in rates is very impressive, e.g., in 1945 and 1953 (Fig. 1) and shows that the structure of the Geminids is not

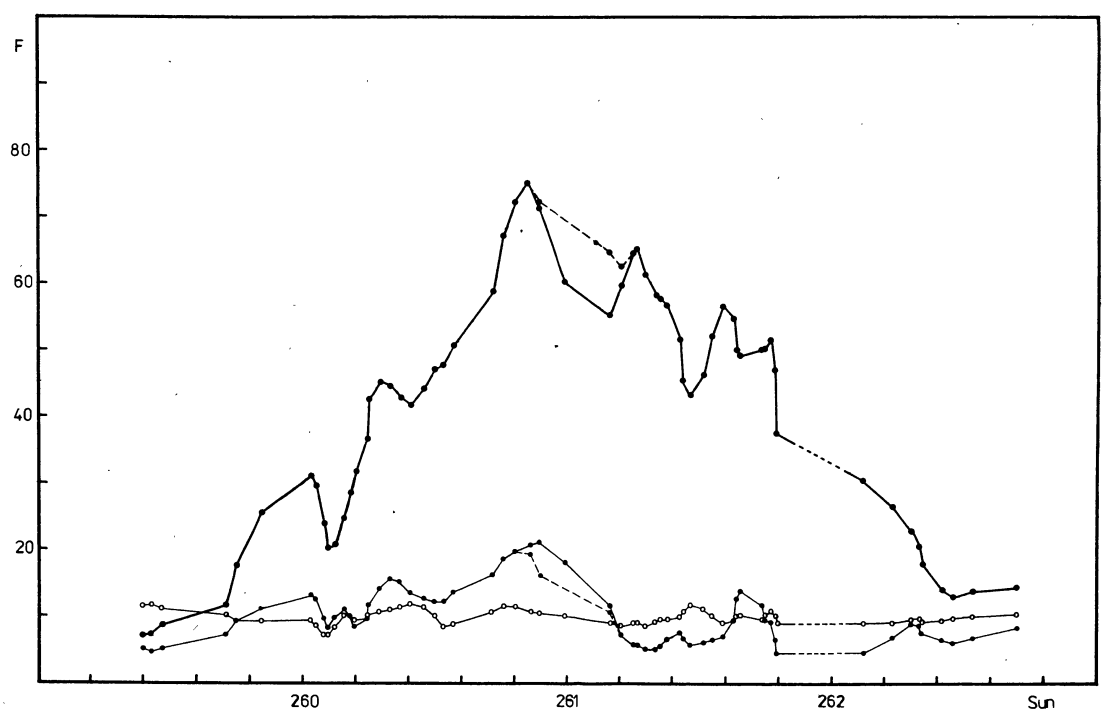

Fig. 2. The smoothed hourly rates of the Geminids (heavy line) and their sporadic background (thin lines, below). For detailed explanation see text.

quite uniform. Unfortunately, the exact peak of activity is not sufficiently defined by our visual observations. From our data it can be inferred that the absolute maximum in different years has occurred within the limits $260°.8 \leq \lambda_{\odot} \leq 261°.2$. This is in perfect agreement with the value of $\lambda_{\odot} = 261°.1$ listed by Millman and McKinley (1963). On the other hand in his "Working List of Meteor Streams" Cook (1973) gives a value of $\lambda_{\odot} = 261°.7$ which is distinctly outside the limits set by our data.

In Fig. 2, as a line with full circles, the smoothed sporadic background rates are plotted, and for a comparison also the standard sporadic rates (open circles). The standard rates are based on the analysis by Štohl (1969) of the sporadic meteor rates in 1944—1953, from the observations made at the Skalnaté Pleso Observatory. In his analysis the relative sporadic rates are determined for different solar longitudes and Local Time. From the comparison of the two distributions of the sporadic rates it appears that their contribution is overestimated in some years.

This might be a result of using a stricter criterion for shower membership, especially in the earlier observations. As a matter of fact, if a meteor appears at a great angular distance from the observer's line of sight, he cannot be absolutely certain about the direction of flight which is used as a primary criterion for the shower membership. It depends on whether such sightings are classified as sporadic or shower meteors. If the number of observers in the team is high enough, the coverage of the sky becomes better, and the indeterminate cases can be resolved by a simultaneous recording by the observer in a more favourable position. This was mostly not the case in the earlier observations with three observers, on the average, watching at a time. It is therefore surmised that a wrong classification of some Geminids as sporadic meteors was the main reason of the lack of stability of the sporadic rates.

The curve of activity shown in Fig. 2 is rather steep. Using the definition of shower duration introduced by Millman, i.e., the time interval between the instants when the shower strength is roughly one-fourth of the maximum value, we obtain 2.6 days, in spite of some smoothing being involved. This is substantially less than the value of 6.0 days listed by Millman and McKinley (1963), and compares better with the photographic data (McCrosky and Posen, 1961), and with the compilation by Cook (1973).

Figure 1, with the data points distinguished by the year of observations, does not show any appreciable time-dependent shifts. This is somewhat surprising because the shower should exhibit a perturbational regression of the nodal line, amounting to $-1°.62$ per century according to the computations by Plavec (1950). Another figure analogous to Fig. 1, which is not reproduced here, was plotted with the solar longitude data corrected for this perturbing effect; the dispersion of individual values became somewhat greater rather than smaller. Curiously enough, a better reproduction by a composite curve is even obtained when the perturbation is taken with the opposite sign. The theoretical value of the displacement, $0°.5$ between the first and last observed apparitions, should be just large enough to be resolved. A definite answer has to await supplementary observations during the coming returns which, combined with those of 1944—1949, should provide a reliable base for determining the motion of the node to within $\pm 0°.5$ per century. At present, however, there is no verification of this effect.

While the absence of the nodal regression appears somewhat strange, it is in agreement with the identification of a number of Geminid fireballs in the ancient records compiled by Astapovich and Terenteva (1968). These two authors suggest that the node of the Geminid orbit has remained practically unchanged in the course of nine centuries. The situation contrasts with that of the Quadrantid shower which is in many respects similar to the Geminid shower. Although the Quadrantids have been observed less extensively, the regression of their node has already been definitely established (Hawkins and Southworth, 1958; Hughes, 1972). It is true that their peak is sharper and hence better defined. Nevertheless, the lack of secular variation in the Geminid stream appears to be real, and awaits confirmation and explanation.

4. Changes in Magnitude Distribution of the Geminids

Another aspect of stream structure, which can be examined on the bases of the present observations is the magnitude distribution of the Geminids and its possible variations within the stream. A previous study of the problem by Kresáková (1966), based partly on the same visual data from the Skalnaté Pleso Observatory, revealed no pronounced irregularity in the magnitude distribution of the Geminids, neither in the direction from the stream's centre towards its boundary, nor from the inner to the outer boundary relative to the Sun. The mean magnitude of the Geminids merely showed irregular variations within some ranges. In this case, however, the material was only subdivided into four parts along the path traversed by the Earth through the stream, separated by solar longitudes of 259°.0, 261°.0 and 262°.5, respectively. Having at our disposal complete and extended records of the visual data, it appeared reasonable to search for finer changes in the magnitude distribution in the course of the activity of the Geminid shower.

The mean magnitudes $\bar{m}_+$ of the Geminid meteors, together with the corresponding numbers n_+ of magnitude estimates of the Geminids for each hour of observation are shown in Table 4, columns 10 and 12. It may be noted that in some cases numbers n_+ are different from the corresponding numbers of records used for the hourly rates, because of missing magnitude estimates. To reduce the strong influence of the random variations in the number of very bright meteors on the calculated mean magnitudes, the values $\bar{m}^*_+$ are also given in Table 4, column 11, defined arbitrarily as

$$\bar{m}^* = \frac{\sum_{m>0}^{m_{\rm lim}} m n_m}{\sum_{m=-\infty}^{m_{\rm lim}} n_m}. \qquad (4)$$

This actually means that the values $\bar{m}^*$ (thereinafter referred to as effective mean magnitudes) represent the means with all bright meteors (with $m<0$) taken as those of magnitude $m=0$. The corresponding values $\bar{m}_-$, $\bar{m}^*_-$ and n_- for the sporadic meteors, and for each interval, are given in Table 4, columns 13, 14 and 15.

The values of the effective mean magnitudes $\bar{m}^*_+$ of the Geminids for the period in between $259°.0 \leqslant \lambda_\odot \leqslant 263°.0$ are marked in Fig. 3 by dots. The size of any individual dot indicates the weight of the particular value of $\bar{m}^*_+$, according to the square root of the number of magnitude estimates used for its calculation. The curve in Fig. 3 represents the smoothed values of the effective magnitudes $\bar{m}^*_+$, calculated from 5 adjacent points with relative weights of 1, 4, 6, 4, 1, respectively. One can see that the individual values of $\bar{m}^*_+$ are dispersed considerably. However, there is a definite systematic predominance of brighter mean magnitudes in the periods following immediately after

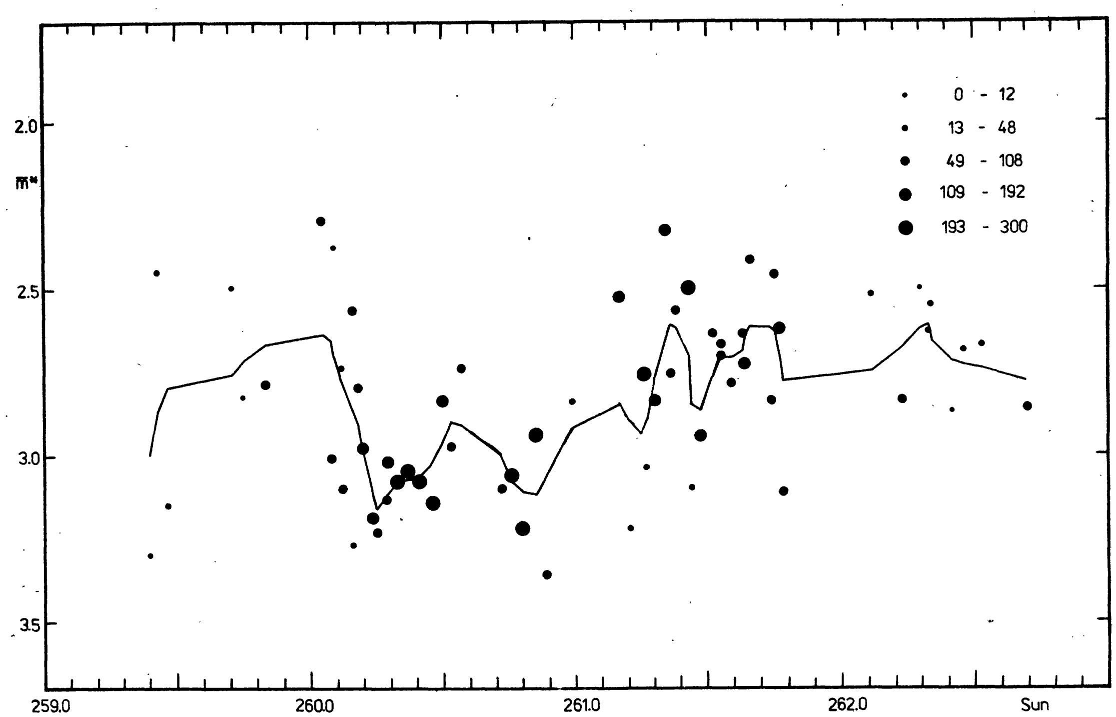

Fig. 3. The effective mean magnitudes of the Geminids, $\bar{m}^*_+$, plotted against solar longitude. The sizes of the dots indicate the number of individual magnitude data used for forming the mean.

the maximum of the shower activity at $\lambda_{\odot} \approx 261\overset{\circ}{.}0$.

As far as the spread of the values $\bar{m}_{+}^{*}$ is concerned, there are some periods with unusually high number of bright shower meteors. Among them the most prominent are those at $\lambda_{\odot} \approx 260\overset{\circ}{.}1$ (1947, 1958), $261\overset{\circ}{.}3$ (1946) and $261\overset{\circ}{.}8$ (1953). Some other are also expressive, e.g. at $259\overset{\circ}{.}4$ (1946), though they might be influenced by worse observing conditions. The enhancement of brighter meteors does not appear in different years at the same solar longitudes. This tendency lends support to the previous conclusions by Kashcheev and Lebedinets (1959) and by Kresáková (1966) that there are isolated regions in the Geminid meteor stream where the relative number of larger particles is enhanced.

The systematic change in $\bar{m}_{+}^{*}$ towards brighter magnitudes right after the maximum of the shower activity deserves a special attention. Though it seems to be impressive, it might be influenced by different observing conditions in various years and nights. One way to verify its reality is to compare the trend with the effective mean magnitudes $\bar{m}_{-}^{*}$ of the sporadic meteors. Unfortunately, the number of sporadic meteors n_{-} is much lower in comparison with the number of the Geminids n_{+} around the maximum of the activity. Also, as already mentioned in the preceding section, there are cases where the discrimination between sporadic and shower meteors may be systematically biased. We can compare, however, more extensive periods, say, those before and after $\lambda_{\odot} \approx 261\overset{\circ}{.}0$. In both of these periods we deal with records obtained in 5 different years, and for 4 years observations from both periods are available. Even this fact suggests that the systematic change in the mean magnitude is not caused by different observing conditions.

Table 5 gives the mean magnitudes $\bar{m}_{+}$ and $\bar{m}_{+}^{*}$ for 15 intervals of solar longitude with approximately the same numbers of magnitude records $\Sigma n_{+} \approx 400$ of the Geminid meteors. The table also gives the corresponding values of the magnitude distribution index $\varkappa$, defined by the equation

$$n(m) = n(0)\,\varkappa^{m}. \qquad (5)$$

The relation between $\varkappa$ and $\bar{m}$ for the Skalnaté Pleso visual data was derived earlier by Kresáková (1966). The resulting values, together with the corresponding values of the effective mean magnitude $\bar{m}^{*}$, are given in Table 6.

Figure 4 shows the changes of the distribution index $\varkappa$ for the Geminids with solar longitude $\lambda_{\odot}$. Again, the change of $\varkappa$ immediately after the maximum of the shower stands out clearly, occurring around the solar longitude $\lambda_{\odot} \approx 261\overset{\circ}{.}0$. To check the reality of this change, we can adopt $\varkappa = 2.70$ as a boundary value between the periods of low ($260° < \lambda_{\odot} < 261°$) and high ($261° < \lambda_{\odot} <$

Table 5

Sun	$\bar{m}_{+}$	$\bar{m}_{+}^{*}$	$\varkappa_{+}$	$\varkappa_{+}^{*}$	n_{+}
259.96	2.71	2.82	2.55	2.61	367
260.20	2.94	2.97	2.85	2.83	428
260.28	3.08	3.09	3.08	3.05	334
260.35	3.04	3.07	3.00	3.01	451
260.44	3.09	3.11	3.09	3.08	398
260.58	2.90	2.92	2.79	2.76	379
260.78	3.14	3.14	3.19	3.14	411
260.87	3.00	3.01	2.94	2.90	421
261.22	2.71	2.72	2.55	2.48	423
261.32	2.67	2.71	2.51	2.47	349
261.42	2.53	2.59	2.37	2.33	339
261.52	2.68	2.76	2.52	2.53	356
261.62	2.66	2.72	2.50	2.48	378
261.74	2.52	2.59	2.36	2.33	356
262.25	2.74	2.84	2.58	2.64	382
All	2.84	2.88	2.73	2.76	5772

Table 6

$\varkappa$	$\bar{m}^{*}$	$\bar{m}$
2.00	2.229	1.982
2.10	2.353	2.165
2.20	2.464	2.317
2.30	2.564	2.448
2.40	2.655	2.562
2.50	2.738	2.663
2.60	2.814	2.754
2.70	2.884	2.834
2.80	2.949	2.908
2.90	3.009	2.975
3.00	3.065	3.037
3.10	3.118	3.094
3.20	3.167	3.147
3.30	3.214	3.197
3.40	3.258	3.243
3.50	3.299	3.286
3.60	3.338	3.327
3.70	3.376	3.366
3.80	3.411	3.403
3.90	3.445	3.438
4.00	3.478	3.472

263°) values of the mean magnitudes. We then have the grand means of $\varkappa$ for the shower and the sporadic meteors as follows

$\lambda_\odot$	$\varkappa_+$	$\varkappa_-$
260—261	2.95	3.50
261—263	2.52	3.45
$\Delta\varkappa$	0.43	0.05

While in $\varkappa_+$ there is a difference of $\Delta\varkappa_+ = 0.43$ between the two periods, the values $\varkappa_-$ of the sporadic meteors are almost identical for both periods, with $\Delta\varkappa_- = 0.05$. We should note that in these values the observations from 1974 are not included, since their system did not allow to derive dependable data on sporadic magnitudes; the 1974 values were obviously excluded both for the shower and the sporadic meteors in this particular case.

We can conclude that the visual data from the Skalnaté Pleso Observatory suggest a sudden change in the magnitude distribution of the Geminids, occurring at the maximum of their activity, or at least a gradual change during the two days surrounding the maximum. This actually means that the larger particles, responsible for a decrease in the distribution index $\varkappa$ after the maximum, tend to concentrate towards the outer edge of the Geminid stream. The finding is in qualitative agreement with the theoretical expectation of how the selective Poynting—Robertson effect should change the structure of meteor streams by letting the smaller particles spiral inwards (Wyatt and Whipple, 1950).

Unfortunately, our visual data recorded before $\lambda_\odot \approx 259°$ and after $\lambda_\odot \approx 263°$ are too scarce, comprising only 2% of all our data on the Geminids, to permit any significant conclusions about the behaviour of $\varkappa_+$ in the boundary parts of the stream. It is possible that the wings of the stream build up by stronger gravitational perturbations, are less sensitive to the Poynting—Robertson separation than the immediate neighbourhood of its core.

As to our knowledge, this is the first direct proof of a magnitude separation within the Geminid stream based on visual observation alone. It may be noted that there are analogous supporting results of radar observations capable of detection of smaller particles. For example, Šimek (1973) locates the maximum of the long-duration echoes ($\geqslant 3$ s) at $\lambda_\odot = 261^\circ.2$ but that of the short-duration echoes (< 0.3 s) at $\lambda_\odot = 260^\circ.1$. The radar observations of fainter meteors yield systematically earlier maxima, e.g. $\lambda_\odot = 260^\circ.3$ for bright subvisual meteors (Webster et al., 1966), and even $\lambda_\odot = 259°$ for faint subvisual meteors (Forti, 1968). On the other hand, the peak rate of the bright photographic meteors was found to occur until at $\lambda_\odot = 261^\circ.8$ (Whipple, 1954). For a summary of relevant data see Tables 5 of the papers of Hajduk et al. (1974) and of Šimek (1975). The

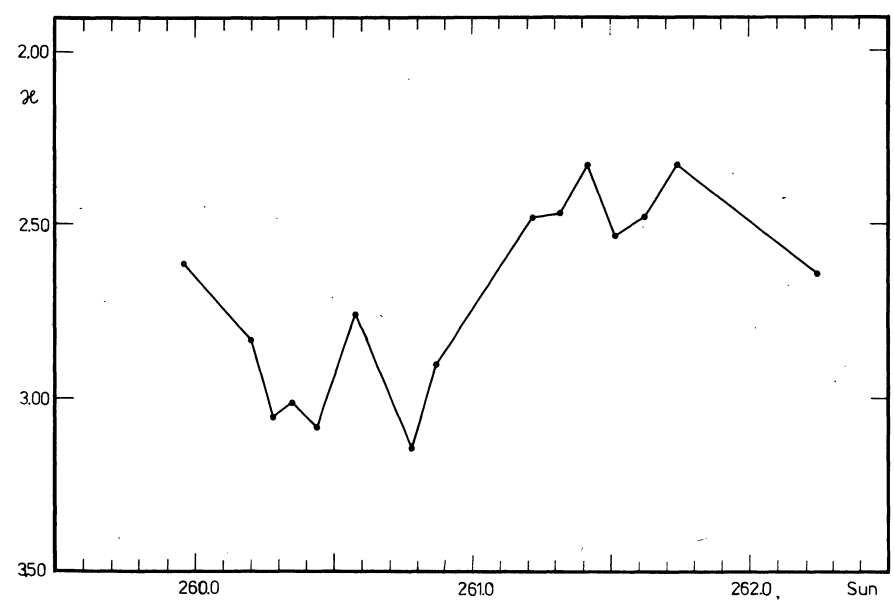

Fig. 4. The magnitude distribution index, $\varkappa_+$, of the Geminids, plotted against solar longitude. Individual dots have approximately the same weight.

dependence of the time of maximum on meteor magnitude can be roughly approximated by

$$\lambda_\odot = 261\overset{\circ}{.}6 - 0\overset{\circ}{.}2\ \bar{m}_+ . \tag{6}$$

However, the spread of the individual values is much larger, and the interpretation is complicated by the perturbations in nodal longitude referred to in the preceding section. Hence the purely empirical relation (6) must be taken with caution. A comparison also suggests that the relation between $\bar{m}_+$ and $\lambda_\odot$ is nonlinear, with a steeper variation in longitude in the range of fainter meteors. This would also agree with theoretical expectation, but more observational support is evidently needed.

5. Conclusions

From the set of our 6000 homogenized records of the Geminid meteors, obtained at nine returns of the shower, the following main conclusions can be drawn:

1. As compared with other meteor showers, the annual activity of the Geminids appears to be relatively stable. Short-term irregular variations within individual returns seem to be nearly equally pronounced as the long-term variations from one year to another. The maximum hourly rate of meteors reduced to a standard naked-eye observer with unlimited field of view, perfect atmospheric conditions, and radiant point in the zenith, is about 80. The duration measured between points where the strength is one-fourth of the maximum value is about 2.5 days, i.e. considerably less than assumed earlier.

2. The peak hourly rate occurs at $\lambda_\odot = 261\overset{\circ}{.}0 \pm 0\overset{\circ}{.}2$. Although our observations extend over a period of 30 years, during which the nodal line should have regressed by $-0\overset{\circ}{.}5$, we failed to obtain an observational verification of this effect by a shift of the curve of hourly rates. When perturbational corrections are applied, the dispersion of the observed rates with respect to the standard curve tends even to increase.

3. The observed magnitude distribution of the Geminids definitely confirms the earlier suggestion that their increament with decreasing brightness ($\varkappa_+ = 2.75$) is considerably slower than that of the sporadic background ($\varkappa_- = 3.5$). This means that with each magnitude class the proportion of shower to sporadic meteors decreases by some 20%. In the inner part of the stream, the magnitude distribution index of the Geminids exhibits a decrease from about $\varkappa_+ = 3.0$ at $\lambda_\odot = 260\overset{\circ}{.}5$ to $\varkappa_+ = 2.5$ at $\lambda_\odot = 261\overset{\circ}{.}5$. This change is in qualitative agreement both with the results of the radio observations and with the theoretical expectation based on the Poynting—Robertson effect.

References

ASTAPOVICH, I. S., TERENTEVA, A. K. (1968): IAU Symp., *33*, 308.

COOK, A. F. (1973): In: Evolutionary and Physical Properties of Meteoroids. NASA SP-319, Washington, 183.

FORTI, G. (1968): IAU Symp., *33*, 423.

GRYGAR, J., KOHOUTEK, L., KVÍZ, Z., MIKUŠEK, J. (1962): Bull. Astron. Inst. Czech., *13*, 108.

GUTH, V. (1941): Mitt. Beob. Tschech. Astron. Gesellschaft, *6*, 9.

HAJDUK, A., McINTOSH, B. A., ŠIMEK, M. (1974): Bull. Astron. Inst. Czech., *25*, 305.

HAWKINS, G. S., SOUTHWORTH, R. B. (1958): Smithson. Contr. Astrophys., *3*, 1.

HUGHES, D. W. (1972): Observatory, *92*, 41.

KASHCHEEV, B. L., LEBEDINETS, V. N. (1959): Astron. Zh., *36*, 629.

KRESÁK, Ľ., PORUBČAN, V. (1970): Bull. Astron. Inst. Czech., *21*, 153.

KRESÁKOVÁ, M. (1966): Contr. Astron. Obs. Skalnaté Pleso, *3*, 75.

McCROSKY, R. E., POSEN, A. (1961): Smithson. Contr. Astrophys., *4*, 15.

MILLMAN, P. M., McKINLEY, D. W. R. (1963): In: The Moon, Meteorites and Comets. The Solar System. Vol. 4. Chicago, Chicago Press, 674.

PLAVEC, M. (1950): Nature, *165*, 362.

PORUBČAN, V., ŠTOHL, J. (1978): Contr. Astron. Obs. Skalnaté Pleso, *8*, 71.

ŠIMEK, M. (1973): Bull. Astron. Inst. Czech., *24*, 213.

ŠIMEK, M. (1975): Bull. Astron. Inst. Czech., *26*, 1.

ŠTOHL, J. (1969): Contr. Astron. Obs. Skalnaté Pleso, *4*, 25, 46.

WEBSTER, A. R., KAISER, T. R., POOLE, L. M. G. (1966): Monthly Not. Roy. Astron. Soc., *133*, 3.

WHIPPLE, F. L. (1954): Astron. J., *59*, 201.

WYATT, S. P., WHIPPLE, F. L. (1950): Astrophys. J., *111*, 134.

METEORICKÝ ROJ GEMINÍD: AKTIVITA A FUNKCIA JASNOSTI

V. PORUBČAN, M. KRESÁKOVÁ, J. ŠTOHL

Astronomický ústav Slovenskej akadémie vied, Bratislava, Československo

Súhrn

V práci sa analyzujú vizuálne pozorovania meteorického roja Geminíd, obsahujúce viac ako 8000 meteorov, zaregistrovaných počas 9 návratov roja v rokoch 1944—1974 na observatóriu na Skalnatom Plese. Uvedená stredná krivka aktivity ukazuje, že ročná aktivita Geminíd je v porovnaní s inými rojmi pomerne stála. Krátkodobé nepravidelné variácie v období jednotlivých návratov sa vyskytujú približne v rovnakej miere ako dlhodobé variácie od jedného roku k druhému. Maximálna frekvencia Geminíd, prevedená na štandartného pozorovateľa pri ideálnych atmosferických podmienkach a s radiantom v zenite, je približne 80 meteorov za hodinu. Trvanie aktivity roja medzi momentmi, v ktorých dosahuje štvrtinu maximálnej aktivity, nepresahuje 2,6 dňa, čo je značne menej, než sa predtým predpokladalo. Maximum aktivity nastáva pri dĺžke Slnka $\lambda_{\odot}=261°,0\pm0°,2$. Napriek dlhodobému 30-ročnému obdobiu pozorovaní sa nepotvrdila predpovedaná regresia uzla dráhy Geminíd.

Pozorovaná funkcia jasnosti Geminíd presvedčivo potvrdzuje predchádzajúce závery o tom, že narastanie počtu meteorov roja pri poklese jasnosti o jednu hviezdnu veľkosť je pomalšie ($\varkappa_{+}=2,75$) ako pri meteoroch sporadického pozadia ($\varkappa_{-}=3,50$). Z toho vyplýva, že pri poklese jasnosti o jednu magnitúdu zníži sa podiel počtu rojových a sporadických meteorov o 20%. Pre vnútornú časť roja klesá index funkcie jasnosti z $\varkappa_{+}=3,0$ pri $\lambda_{\odot}\approx260°,5$ na $\varkappa_{+}=2,5$ pri $\lambda_{\odot}\approx261°,5$. Táto zmena je v kvalitatívnej zhode s výsledkami radarových pozorovaní Geminíd a s teoretickým predpokladom vychádzajúcim z Poyntingovho—Robertsonovho efektu.

МЕТЕОРНЫЙ ПОТОК ГЕМИНИД: АКТИВНОСТЬ И РАСПРЕДЕЛЕНИЕ ЗВЕЗДНЫХ ВЕЛИЧИН

В. ПОРУБЧАН, М. КРЕСАКОВА, Я. ШТОЛ

Астрономический институт Словацкой академии наук, Братислава, Чехословакия

Резюме

В работе изучаются визуальные наблюдения метеорного потока Геминид, насчитывающие более чем 8000 метеоров, зарегистрированных в течение 9 обращений роя в 1944—1974 гг. в обсерватории Скалнате Плесо. Приведенная средная кривая активности потока показывает, что годичная активность Геминид по сравнению с другими потоками является относительно постоянной. Кратковременные неправильные вариации во время отдельных возвращений встречаются с той же самой выразительностью как долговременные вариации от одного года к другому. Максимальное часовое число метеоров, переведенное на стандартного наблюдателя при идеальных атмосферных условиях с радиантом в зените, достигает 80. Продолжительность активности потока, ограничена моментами, когда численность метеоров потока достигает одну четвертую их максимальной численности, не превышает 2,6 дня, т. е. значительно короче прежных предположений. Активность оказывается максимальной при долготе Солнца $\lambda_{\odot}=261°,0\pm0°,2$. Вопреки долговременному, 30-ти летнему периоду наблюдений предсказанной регрессии узла найти не удалось.

Наблюдаемое распределение звездных величин Геминид убедительно подтверждает прежные заключения о том, что увеличивание числа Геминид на одну звездную величину при переходе к более слабым метеорам намного меньше ($\varkappa_{+}=2,75$) по сравнению с увеличиванием числа метеоров спорадического фона ($\varkappa_{-}=3,50$). Это означает, что при изменении яркости метеоров на одну звездную величину относительное число метеоров потока и спорадических метеоров изменяется на 20%. Для внутренней части роя индекс распределения звездных величин Геминид показывает падение с $\varkappa_{+}=3,0$ при $\lambda_{\odot}=260°,5$ на $\varkappa_{+}=2,5$ при $\lambda_{\odot}=261°,5$. Это изменение находится в качественном согласии с результатами радиолокационных наблюдений и с теоретическим предположением, основанным на эффекте Пойнтинг—Робертсона.