

CHANGES IN THE ACTIVITY OF THE PERSEID METEOR SHOWER 1944-1953

J. Zvolánková

Astronomical Institute, Slovak Academy of Sciences, Dúbravská cesta,  
842 28 Bratislava, Czechoslovakia

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ABSTRACT. On the basis of more than 17 000 visual records of Perseids obtained at the Skalnaté Pleso Observatory over a period of 9 years, using the zenithal exponent  $\Upsilon = 1.47$  in the reduction factor  $\cos^\Upsilon z$  and introducing annual coefficients, the activity of the Perseid meteor shower in the years 1944-1953 (with the exception of 1945) is compared. A considerable difference is found between the individual years as can be seen from the annual coefficients which cover the interval  $\langle 0.73; 1.87 \rangle$ . It appears that the activity of the Perseids before and after their maximum is asymmetrical.

ИЗМЕНЕНИЯ В АКТИВНОСТИ МЕТЕОРНОГО ПОТОКА ПЕРСЕИД В 1944-1953 ГГ. На основании свыше 17 000 наблюдений Персеид невооруженным глазом полученных в Обсерватории Скалнатэ Плесо в течение 9 лет, используя показателя степени  $\Upsilon = 1.47$  у поправочного фактора  $\cos^\Upsilon z$  и введением годовых поправочных коэффициентов была сравнена активность потока Персеид в годах 1944-1953 (мимо 1945 г.). Обнаружено было значительное различие в активности в отдельных годах. Для  $\Upsilon = 1.47$  годовые поправочные коэффициенты в интервале  $\langle 0.73; 1.87 \rangle$ . Подтвердилась асимметрия активности потока Персеид до максимума и после максимума.

ZMENY AKTIVITY ROJA PERZEÍD V R. 1944-1953. Na základe viac než 17 000 vizuálnych záznamov Perzeíd získaných na Observatóriu Skalnaté Pleso počas 9 rokov použitím exponentu  $\Upsilon = 1.47$  v redukčnom faktore  $\cos^\Upsilon z$  a zavedením roč-

ných koeficientov bola porovnaná aktivita roja Perzeíd v rokoch 1944-1953 (okrem r. 1945). Zistil sa značný rozdiel v jednotlivých rokoch, ako to vidno z ročných koeficientov, ktoré sú pre  $\gamma = 1.47$  v intervale  $\langle 0.73; 1.87 \rangle$ . Potvrdila sa aj asymetria aktivity Perzeíd pred maximom a po maxime.

## 1. INTRODUCTION

The Perseids are the best known and best observable of all cometary showers of the Northern Hemisphere. They appear annually between July 20 and August 21 (according to observations at Skalnaté Pleso). Various authors give different duration of the shower activity, e.g., Wright and Whipple (1953) give 28 days, from July 28 to August 24. Maximum of the shower occurs at the solar longitude  $139^\circ$  (Cook, 1973), i.e. on August 12/13. According to Wright and Whipple (1953), 62% of all Perseids are observed within four days, between August 10 and 13.

The permanent character of the shower, associated with a comet of revolution period  $P = 120$  years (P/Swift-Tuttle), indicates that it originated at least thousands of years ago. The originally denser parts became gradually dispersed almost uniformly along the whole orbit. The large width of the stream, 65 million kilometers according to Whipple and Wright (1954), as well as the small number of telescopic Perseids (Kresáková, 1957) are also evidence of their ancient origin.

The activity of the Perseids around their maximum is high. As a rule, the hourly rate of 50 - 60 meteors is considered to be normal at the maximum for one visual observer under good observing conditions. The only case of an extremely high hourly rate occurred in the year of the last return of the comet (Imoto and Hasegawa, 1958); unfortunately, it is only recorded in a Chinese chronicle without more detailed quantitative data.

In this paper visual observations of the Perseid meteor shower are analysed as obtained in the years 1944-1953 (with the exception of 1945) as a part of the program of systematic visual observations of sporadic and shower meteors conducted at the Skalnaté Pleso Observatory. The data range among the best in the world as to their extent and homogeneity. In the course of the 10 years, the method of observation did not change substantially. The group of observers usually consisted of a recorder and of four observers who watched the sky at an elevation of  $45^\circ$  above the horizon in the four main directions (E, S, W, N). The cloudiness (the percentage of the observed area covered by clouds) was recorded at intervals of 10 minutes in each direction; if it changed rapidly, it was recorded every 5 minutes. The limiting stellar magnitude was not recorded because, as demonstrated by Kresáková (1966), it is practically constant at the high altitude of the Skalnaté Pleso Observatory, 1783 m above sea level.

## 2. THE DATA AND THEIR ANALYSIS

In order to eliminate inhomogeneity of the data, observations during which cloudiness exceeded 30%, as well as observations affected by the moonlight (with the exception of 1946), and all observations of observers with little experience were omitted.

Tab. 1

Year	$M_c$	$P_c$	P
1944	4 322	2 827	1 488
1946	7 129	2 909	2 599
1947	2 044	633	392
1948	2 786	1 025	792
1949	779	189	137
1950	2 573	1 542	1 121
1951	4 512	2 395	1 694
1952	3 535	1 863	215
1953	5 382	3 846	1 921
$\Sigma$	33 062	17 229	10 359

Table 1 summarizes the total number of observed meteors  $M_c$ , of the total number of observed Perseids  $P_c$ , of the number of Perseids P accepted for further processing. A list of observers is given in Table 2.

The observed Perseids were divided into half-hour intervals. For each of these intervals and for each observer p the number of observed Perseids  $N_p$ , the net time  $t_p$  for which he observed and the average cloudiness were determined. For the middle of each interval at twilight the depression of the Sun was calculated. These data and the personal coefficients were used to calculate the corrected hourly rates per one observer according to the formula

$$f_o = 60 \tau \sum_1^{\epsilon} N_p \left[ \sum_1^{\epsilon} t_p / k_{op} k_{1p} \right]^{-1} \quad (1)$$

where  $f_o$  is the corrected hourly rate,  $N_p$  the number of meteors observed by observer p within the respective interval,  $t_p$  the net observing time,  $k_{op}$  the cloudiness coefficient,  $k_{1p}$  the personal coefficient,  $\epsilon$  the total number of observers who took part in the observations within the given interval and  $\tau$  is the twilight coefficient.

The cloudiness coefficients  $k_{op}$  calculated by Guth (1941) were used in this paper. Guth considered two types of cloudiness: a) a circular cloud, and b) a continuous cloud cover limited by a great circle. The two coefficients are the same up to the cloudiness of 30%. Since the records do not specify the type of cloudiness, all observations at which the cloudiness exceeded 30% were eliminated from further analysis.

The personal coefficients  $k_{1p}$  for the individual observers are given in Table 2 as determined by Štohl (1969). Besides these coefficients, the table

also gives an abbreviation for each observer, the sum of all observed meteors and the total net observing time in minutes, as used in the present paper.

Tab. 2

Name	Abbr.	$k_{1p}$	$N_p$	$t_p$
Bajcár R.	Bj	1.05	392	1 029
Bakoš G.	Bk	1.93	7	319
Bečvář A.	T	1.13	1 343	6 264.5
Blahová N.	Ba	1.20	24	438
Ceplecha Z.	Ce	1.44	134	458
Čajda I.	C	1.77	15	50
Dědek S.	De	2.00	389	1 048
Drozd L.	D	1.31	405	1 048.5
Dzubák M.	M	1.08	509	4 094
Frajová H.	Fo	1.05	9	366
Guth V.	G	1.74	446	1 221
Hájková M.	Ha	1.38	304	839.5
Hartmanová M.	H	1.52	47	423
Ivan J.	I	1.17	332	1 011.5
Jančík T.	J	1.51	147	543
Kiss V.	Ki	1.59	148	954
Kresák Ľ.	K	1.07	1 093	6 068.5
Kresáková M.	Ka	1.11	62	351.5
Kvíz Z.	Q	2.14	2	70
Leftus V.	Le	1.59	216	1 165
Lexa J.	X	2.68	317	1 048
Maleček B.	Mk	1.84	27	348
Malovec J.	Mc	1.77	161	661
Mrkos A.	A	0.92	919	3 210.5
Olejník Š.	O	1.41	205	852
Pajdušáková Ľ.	L	1.00	1 869	7 522
Plavec M.	Pc	1.35	140	855
Podstanická R.	Po	1.62	4	118
Rajchl J.	Ra	1.43	1	67
Sitár J.	S	1.26	405	1 612.5
Štohl J.	St	0.96	8	118
Šuba Š.	Su	1.30	2	122.5
Uhlár J.	U	1.27	219	938
Vadovič F.	V	1.44	5	210
Vranová M.	Vr	1.31	53	605.5
			10 359	46 050

Since the beginning or end of a large number of observations occurred at the astronomical twilight, a twilight correction had to be made using the twilight coefficient  $\tau$ , as determined by the author elsewhere (Slančíková, 1975).

The coefficients  $\tau$  were calculated for the Perseids using the value  $\alpha = 2.6$ , as determined by Kresáková (1966), and for the sporadic background using the value  $\alpha = 3.5$ , also according to Kresáková (1966). The values of  $\tau$  (rounded off to two decimal places) for different solar depressions are given in Tab.3.

Tab. 3

-h°	$\tau$ for		-h°	$\tau$ for	
	$\alpha = 2.6$	$\alpha = 3.5$		$\alpha = 2.6$	$\alpha = 3.5$
10.0	2.54	3.39	12.6	1.23	1.30
10.2	2.36	3.08	12.8	1.18	1.25
10.4	2.19	2.80	13.0	1.15	1.20
10.6	2.05	2.56	13.2	1.12	1.16
10.8	1.92	2.35	13.4	1.09	1.12
11.0	1.80	2.16	13.6	1.07	1.09
11.2	1.70	2.00	13.8	1.05	1.06
11.4	1.61	1.86	14.0	1.03	1.04
11.6	1.52	1.74	14.2	1.02	1.02
11.8	1.45	1.63	14.4	1.01	1.01
12.0	1.38	1.53	14.6	1.00	1.00
12.2	1.33	1.45	14.8	1.00	1.00
12.4	1.27	1.37	15.0	1.00	1.00

The corrections mentioned above were used to calculate the hourly rates  $f_o$  for all half-hour intervals.

To be able to compare all these hourly rates with each other, the rates had to be reduced to the radiant in the zenith. We denote the zenithal hourly rate per one observer as  $f_z$  and the reduction factor as  $\cos \gamma_{zR}$ . Hence,

$$f_z = \frac{f_o}{\cos \gamma_{zR}} \quad (2)$$

One of the most serious difficulties in observing meteors is the Moon. In the interval between the first and last quarter it illuminates the sky to such an extent that we can only see the brightest stars and, obviously, also only the brightest meteors. The moonlight adds to the brightness of the night sky. Due to the Moon, the brightness of the sky behaves in the same way as that of the daytime sky, however, it is reduced in proportion of the illumination by the Moon to that by the Sun. For a full moon this is about  $2.5 \times 10^{-6}$  (Tousey and Koomen, 1953). The increase in the sky brightness due to the Moon only becomes important when the Sun is at least  $10^\circ$ - $12^\circ$  below the horizon. Naturally, this mainly affects the visibility of the region close to the Moon, and is enhanced by cloudiness or atmospheric haze. No observations are made on moonlight nights, unless there are special reasons for doing so.

Extensive observational data from Skalnaté Pleso are available from the year 1946, between July 20, 1946 to August 20, 1946. They include the whole period of the Perseid shower activity, as well as the whole lunation. At the

time of the maximum of the shower's activity the Moon was full. To be able to use this material, it was necessary to include, apart from the corrections already mentioned (personal coefficients, cloudiness, limiting magnitude at twilight), also the correction for the phase of the Moon. In this year, the correction could be applied thanks to a large number of continuous observations. (The total number of observed meteors was 7 129 of which 2 909 were Perseids).

In all the other years, the observations interfered by moonlight were eliminated from further analysis.

### 3. ANNUAL COEFFICIENTS

The Perseids belong to the broadest meteor streams with a relatively regular annual recurrence of the activity curve. However, since the Earth comes very close to the orbit of the parent comet, the hourly rates curve around the maximum is steep, and the maximum may change from year to year as indicated by observations carried out during the various returns (Lovell, 1954).

To be able to compare the activity of the Perseid shower for different years, all observations had to be reduced to the same time scale. The dates were replaced by the solar longitude for the equinox 1950.0. The zenith distance of the radiant, corrected for the zenithal attraction, was also calculated. A Hewlett-Packard 9830 calculator was used to compute the zenith hourly rates for each half-hour interval and these zenith hourly rates were plotted into a graph whose x-axis showed the solar longitude,  $l_{1950}$ , and the y-axis the natural logarithm of the zenith frequency,  $\ln f_z$ . A straight line was then fitted to these data points. The calculation was done separately for the two wings: before the maximum of the Perseid shower activity, and after it.

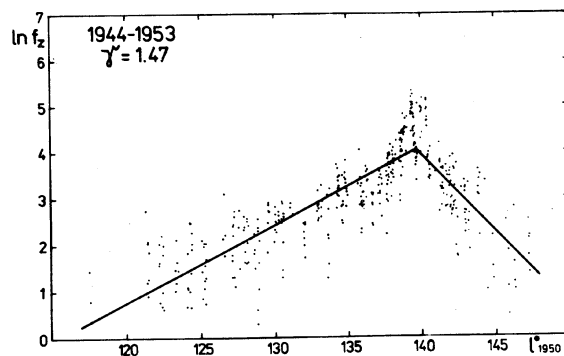


Fig. 1 Mean logarithmic curve of hourly rates for  $Y = 1.47$

The logarithmic curve was plotted separately for each year, as well as for all the years taken together (Fig. 1). By comparing the summary curve with those for the individual years, the annual coefficients  $k_r$  were obtained.

The annual coefficients for the exponent  $\gamma = 1.47$  (Zvolánková, 1983) are given in Table 4.

Tab. 4

Year	$k_r$	$(k_r)^{-1}$	Year	$k_r$	$(k_r)^{-1}$
1944	1.187	0.842	1950	0.986	1.014
1946	0.797	1.255	1951	1.870	0.535
1947	1.380	0.725	1952	1.145	0.873
1948	1.017	0.983	1953	0.730	1.370
1949	1.039	0.962			

The inverse values of the annual coefficients give the relative level of activity of the Perseid shower in the individual years as compared to the mean activity.

Tab. 5

No.	Date	T	$l_{1950}$	$\Sigma N_p$	$\Sigma t_p$	$f_z$	Observers
1	44.8. 9.	19:45	137.14	8	114	21.81	TLMKiD
2		20:15	137.16	11	150	25.76	TLMKiD
3		20:45	137.18	18	122	35.58	TLMKiD
4	44.8.10.	20:15	138.11	28	180	49.67	TLMOKiUH
5		20:45	138.13	28	210	32.92	TLMOKiUH
6		21:15	138.15	43	210	44.93	TLMOKiUH
7		21:45	138.17	44	210	41.07	TLMOKiUH
8	44.8.11.	20:45	139.09	23	49	113.74	TLMDKiUO
9		21:15	139.11	97	240	90.52	TLMDKiUOC
10		21:45	139.13	72	160	90.02	TLMDKiUOC
11	44.8.12.	19:15	139.99	2	14	53.40	TLMUDKiO
12		19:45	140.01	46	205	70.26	TLMUDKiO
13		20:15	140.03	95	210	123.81	TLMUDKiO
14		20:45	140.05	122	210	140.77	TLMUDKiO
15		21:15	140.07	125	210	128.20	TLMUDKiO
16		21:45	140.09	88	210	80.62	TLMUDKiO
17		22:15	140.11	165	210	135.74	TLMUDKiO
18		22:45	140.13	220	210	170.47	TLMUDKiOH
19	44.8.14.	19:45	141.94	6	72	25.19	TMOU
20		20:15	141.96	15	130	31.53	TMOUKi
21		20:45	141.98	27	150	46.82	TMOUKi
22		21:15	142.00	10	150	15.64	TMOUKi
23		21:45	142.02	12	150	16.45	TMOUKi
24		22:15	142.04	16	150	19.40	TMOUKi
25		22:45	142.06	7	84	13.66	TMOUKi
26	44.8.15.	20:45	142.94	6	150	9.34	TLMUKi
27		21:15	142.96	16	150	22.21	TLMUKi

No.	Date	T	$l_{1950}$	$\Sigma N_p$	$\Sigma t_p$	$f_z$	Observers
28	44.8.15.	21:45	142.98	20	150	24.79	TLMUKi
29		22:15	143.00	9	126	12.06	TLMUKi
30		22:45	143.02	8	106	11.17	TLMUKi
31		23:15	143.04	16	150	14.73	TLMUKi
32	44.8.16.	19:45	143.86	6	51	36.20	OMU
33		20:15	143.88	7	90	21.37	OMU
34		20:45	143.90	9	90	24.43	OMU
35		21:15	143.92	12	90	29.08	OMU
36		21:45	143.94	15	144	20.85	OMUTKi
37		22:15	143.96	7	145	8.74	OMUTKi
38		22:45	143.98	18	93	32.85	OMUKi
39	44.8.17.	19:45	144.82	1	66	4.41	TLO
40		20:15	144.84	3	90	8.64	TLO
41		20:45	144.86	1	67	3.42	TLO
42	44.8.18.	21:15	145.84	1	64	2.88	TLM
43		21:45	145.86	4	119	6.15	TLMKi
44		22:15	145.88	1	104	1.59	TLMKi
45	46.7.20.	21:15	117.58	5	171	4.24	TLMKBkMk
46		21:45	117.60	3	167	2.22	TLMKBkA
47	46.7.24.	20:15	121.36	2	22	15.27	MK
48		21:45	121.42	4	146	3.31	KTbKLM
49		22:15	121.44	9	129	7.58	KTbKLM
50		22:45	121.46	6	80	7.92	KMBk
51		23:15	121.48	2	78	2.47	KMBk
52		23:45	121.50	3	65	3.50	KMBk
53	46.7.25.	00:15	121.52	5	60	6.32	KM
54		21:15	122.36	3	135	3.07	MKTbLbK
55		22:15	122.40	11	134	8.98	MKTbLbK
56		22:45	122.42	2	101	1.98	MKTbLbK
57		23:15	122.44	3	90	2.67	TLMK
58		23:45	122.46	2	55	2.67	KM
59	46.7.26.	00:15	122.48	8	84	6.02	LMK
60		00:45	122.50	11	90	7.22	LMK
61		01:15	122.52	1	33	1.85	LMK
62		20:45	123.29	2	84	4.28	TLMKBk
63		21:15	123.31	3	149	2.74	TLMKBk
64		22:45	123.37	4	116	3.24	TMKAKi
65		23:15	123.39	13	137	8.16	TMKAKiL
66		23:45	123.41	7	100	5.13	TMKKiL
67	46.7.27.	00:15	123.43	1	90	0.74	LMK
68		00:45	123.45	4	58	4.25	LMK
69		21:15	124.27	2	90	2.72	LMK
70		22:15	124.31	11	90	11.74	LMK
71		22:45	124.33	2	90	1.92	LMK



No.	Date	T	l <sub>1950</sub>	$\Sigma N_p$	$\Sigma t_p$	$f_z$	Observers
72	46.7.27.	23:15	124.35	5	90	4.37	LMK
73		23:45	124.37	5	90	4.03	LMK
74	46.7.28.	00:15	124.39	9	90	6.66	LMK
75		00:45	124.41	11	90	7.62	LMK
76		01:15	124.43	10	64	9.64	LMK
77		21:15	125.22	10	180	7.21	TLMKAMk
78		21:45	125.24	12	180	7.66	TLMKAMk
79		22:15	125.26	5	176	2.89	TLMKAMk
80		22:45	125.28	6	150	3.41	TLMKA
81		23:15	125.30	4	150	2.08	TLMKA
82		23:45	125.32	10	150	4.75	TLMKA
83	46.7.29.	00:15	125.34	8	145	3.64	TLMKA
84		00:45	125.36	13	148	5.41	TLMKA
85		01:15	125.38	14	136	7.59	TLMKA
86	46.7.30.	20:45	127.12	3	79	5.25	LMK
87		21:15	127.14	4	82	5.93	LMK
88		21:45	127.16	3	88	3.69	LMK
89		22:15	127.18	6	66	8.92	LMK
90		22:45	127.20	9	73	11.00	TLM
91		23:15	127.22	17	120	11.41	TLMK
92		23:45	127.24	6	120	3.69	TLMK
93	46.7.31.	00:15	127.26	26	120	15.17	TLMK
94		00:45	127.28	24	120	13.56	TLMK
95		01:15	127.30	3	68	3.00	TLMK
96		21:15	128.09	4	108	4.95	LMKH
97		21:45	128.11	14	126	12.90	LMKHA
98		22:15	128.13	17	142	12.18	LMKHAMk
99		22:45	128.15	10	109	7.76	LMKA
100		23:15	128.17	8	150	5.10	LMKAH
101		23:45	128.19	17	144	11.06	LMKAHMk
102	46.8. 2.	20:45	129.99	4	77	7.79	TLMK
103		21:15	130.01	12	142	11.14	TLMKH
104		21:45	130.03	13	150	10.20	TLMKH
105		22:15	130.05	20	150	14.03	TLMKH
106		22:45	130.07	26	149	16.56	TLMKH
107		23:15	130.09	19	135	12.00	TLMKH
108		23:45	130.11	18	150	9.59	TLMKH
109	46.8. 3.	23:45	131.07	22	120	16.24	TMKA
110	46.8. 4.	00:15	131.09	17	75	17.89	TLMKA
111		22:15	131.96	7	65	11.53	TLMKA
112		22:45	131.98	15	150	9.67	TLMKA
113		23:15	132.00	15	150	8.37	TLMKA
114		23:45	132.02	14	150	7.16	TLMKA
115	46.8. 5.	00:15	132.04	12	150	5.52	TLMKA

No.	Date	T	$l_{1950}$	$\Sigma N_p$	$\Sigma t_p$	$f_z$	Observers
116	46.8. 5.	00:45	132.06	27	150	11.27	TLMKA
117		01:15	132.08	29	150	11.69	TLMKA
118		22:15	132.92	15	112	14.89	TLMMK
119		22:45	132.94	20	120	16.72	TLMMK
120		23:15	132.96	21	99	18.21	TLMKMK
121		23:45	132.98	28	90	23.22	TLK
122	46.8. 6.	00:15	133.00	16	90	12.28	TLK
123		00:45	133.02	24	90	17.20	TLK
124		01:15	133.04	19	90	12.86	TLK
125		01:45	133.06	7	27	15.71	TLK
126	46.8. 7.	21:45	134.82	9	56	30.41	TLKA
127		22:15	134.84	24	120	33.92	TLKA
128		22:45	134.86	35	120	44.74	TLKA
129		23:15	134.88	45	120	29.51	TLKA
130		23:45	134.90	46	120	27.71	TLKA
131	46.8. 8.	00:15	134.92	43	120	23.95	TLKA
132		00:45	134.94	44	120	22.88	TLKA
133		01:15	134.96	33	118	16.50	TLKA
134		01:45	134.98	24	68	21.12	TLKA
135		20:45	135.74	9	88	26.54	TLKA
136		23:15	135.84	44	120	55.83	TLKA
137		23:45	135.86	28	120	17.09	TLKA
138	46.8. 9.	00:15	135.88	54	120	30.15	TLKA
139		00:45	135.90	49	120	25.56	TLKA
140		01:15	135.92	41	120	20.14	TLKA
141		01:45	135.94	25	84	17.65	TLKA
142		20:45	136.69	4	68	17.55	TLKA
143		21:15	136.71	5	120	11.34	TLKA
144	46.8.10.	20:15	137.63	2	76	9.08	TLKA
145		20:45	137.65	14	120	34.66	TLKA
146		21:15	137.67	9	112	21.14	TLKA
147		21:45	137.69	15	113	31.20	TLKA
148		22:15	137.71	10	117	18.91	TLKA
149		22:45	137.73	14	107	25.97	TLKA
150		23:15	137.75	19	79	46.17	TLKA
151	46.8.11.	00:15	137.79	36	120	48.80	TLKA
152		00:45	137.81	41	120	50.65	TLKA
153		01:15	137.83	47	120	51.36	TLKA
154		01:45	137.85	82	120	42.05	TLKA
155		20:15	138.59	3	64	18.43	TLKA
156		20:45	138.61	8	120	20.84	TLKA
157		21:15	138.63	26	120	59.56	TLKA
158		21:45	138.65	20	120	42.97	TLKA
159		22:15	138.67	25	119	48.07	TLKA

No.	Date	T	$l_{1950}$	$\Sigma N_p$	$\Sigma t_p$	$f_z$	Observers
160	46.8.11.	22:45	138.69	42	106	77.97	TLKA
161		23:15	138.71	36	116	56.15	TLKA
162		23:45	138.73	30	79	65.71	TLKA
163	46.8.12.	00:15	138.75	62	120	82.33	TLKA
164		00:45	138.77	37	100	53.89	TLKA
165		01:15	138.79	70	120	78.97	TLKA
166		01:45	138.81	33	120	37.96	TLKA
167		02:15	138.83	21	32	119.70	TLKA
168		19:45	139.53	13	72	72.90	TLKA
169		20:15	139.55	24	114	74.93	TLKA
170		20:45	139.57	24	120	62.95	TLKA
171		21:15	139.59	26	120	60.60	TLKA
172		21:45	139.61	25	120	52.06	TLKA
173		22:15	139.63	29	100	64.61	TLKA
174		22:45	139.65	23	116	40.16	TLKA
175		23:15	139.67	28	113	45.88	TLKA
176		23:45	139.69	44	120	62.18	TLKA
177	46.8.13.	00:15	139.71	33	112	46.69	TLKA
178		00:45	139.73	30	76	57.43	TKA
179		01:15	139.75	25	120	28.78	TLKA
180		01:45	139.77	44	120	50.63	TLKA
181		02:15	139.79	18	21	150.93	TKA
182	46.8.14.	19:45	141.45	5	87	23.46	TLK
183		20:15	141.47	7	95	26.73	TLKMk
184		20:45	141.49	12	113	37.73	TLKMk
185		21:15	141.51	12	105	36.59	TLKMk
186		21:45	141.53	9	120	21.08	TLKMk
187		22:15	141.55	11	120	23.14	TLKMk
188	46.8.15.	20:15	142.43	2	120	5.68	TLMK
189		20:45	142.45	5	120	12.61	TLMK
190		21:15	142.47	2	96	5.62	TLMK
191	46.8.19.	19:45	146.26	1	36	4.87	TLK
192		20:15	146.28	9	90	15.76	TLK
193		20:45	146.30	2	90	3.18	TLK
194		21:15	146.32	1	75	2.72	TLK
195	46.8.20.	20:15	147.24	8	100	12.15	TLKA
196		20:45	147.26	5	120	5.65	TLKA
197		21:15	147.28	8	120	8.08	TLKA
198		21:45	147.30	4	112	3.90	TLKA
199		22:15	147.32	4	68	8.56	TLKA
200	47.7.25.	23:45	122.21	4	117	4.79	BaMVK
201	47.7.26.	00:15	122.23	7	120	7.53	BaMVK
202		00:45	122.25	5	120	5.03	BaMVK
203		01:15	122.27	2	120	2.14	BaMVK

No.	Date	T	$l_{1950}$	$\Sigma N_p$	$\Sigma t_p$	$f_z$	Observers
204	47.7.27.	23:15	124.10	1	75	1.94	MKBa
205		23:45	124.12	2	90	2.93	MKBa
206	47.7.28.	00:15	124.14	6	119	6.20	MKBaT
207		00:45	124.16	3	120	2.88	MKBaT
208		23:45	125.08	9	150	8.13	LKVMBa
209	47.7.29.	00:15	125.10	5	150	4.19	LKVMBa
210		00:45	125.12	3	150	2.34	LKVMBa
211	47.8.11.	19:45	138.32	2	12	49.85	TLKA
212		20:15	138.34	20	91	67.80	TLKA
213	47.8.12.	21:15	139.34	48	90	119.55	TLK
214		21:45	139.36	52	90	126.21	TLK
215		22:15	139.38	22	60	82.71	TLK
216	47.8.14.	20:45	141.24	1	17	14.79	TM
217		21:15	141.26	17	60	64.04	TM
218		21:45	141.28	13	60	43.68	TMK
219		22:15	141.30	13	53	44.38	TK
220		22:45	141.32	6	24	41.98	T
221	47.8.15.	00:15	141.38	3	15	24.61	G
222		00:45	141.40	17	51	37.18	GL
223		01:15	141.42	5	30	16.83	L
224		01:45	141.44	5	20	24.06	L
225		20:45	142.20	6	30	49.54	M
226		21:45	142.24	4	48	16.27	TLM
227		22:15	142.26	12	120	17.59	TLMK
228		22:45	142.28	20	87	37.35	TMG
229		23:15	142.30	22	90	36.17	TMG
230		23:45	142.32	22	115	25.48	TLMG
231	47.8.16.	00:15	142.34	13	89	18.01	TLMG
232		00:45	142.36	3	51	6.98	TM
233		01:15	142.38	5	36	15.07	GM
234		01:45	142.40	2	5	41.18	G
235		21:15	143.18	2	18	27.16	TM
236		21:45	143.20	3	60	11.76	TM
237		22:15	143.22	1	24	9.52	TL
238		22:45	143.24	2	50	6.48	ML
239		23:15	143.26	4	41	14.00	ML
240	48.7.29.	20:45	126.62	2	18	22.09	TMPc
241		21:15	126.64	3	90	5.82	TMPc
242		21:45	126.66	5	90	8.98	TMLe
243	48.7.30.	20:45	127.58	1	21	10.71	RaMLe
244		21:15	127.60	10	123	15.42	RaMLeTPc
245		21:45	127.62	3	120	4.42	RaMLeTPc
246	48.8. 1.	21:15	129.51	1	32	6.16	TLe
247		21:45	129.53	4	60	11.78	TLePc

No.	Date	T	$l_{1950}$	$\Sigma N_p$	$\Sigma t_p$	$f_z$	Observers
248	48.8. 1.	22:15	129.55	6	60	17.27	LePc
249		22:45	129.57	7	60	18.11	LePc
250		23:15	129.59	9	76	15.28	LePcL
251		23:45	129.61	8	60	14.99	LePcL
252	48.8. 2.	20:45	130.45	3	45	12.62	TLS
253		21:15	130.47	6	85	11.78	TLS
254		21:45	130.49	10	80	18.50	TLS
255		22:15	130.51	2	75	3.63	TLS
256		22:45	130.53	5	37	17.80	TS
257		23:15	130.55	2	60	4.22	PcS
258		23:45	130.57	4	60	7.72	PcS
259	48.8. 3.	00:15	130.59	8	60	14.33	PcS
260		00:45	130.61	8	60	13.37	PcS
261		01:15	130.63	8	60	12.70	PcS
262	48.8. 6.	20:15	134.26	3	20	40.46	SLe
263		20:45	134.28	4	60	15.83	SLe
264		21:15	134.30	6	60	21.03	SLe
265		21:45	134.32	12	60	37.47	SLe
266		22:15	134.34	11	60	30.77	SLe
267		22:45	134.36	17	88	28.86	SLePc
268		23:15	134.38	16	90	24.17	SLePc
269		23:45	134.40	14	85	20.63	SLePc
270	48.8. 7.	00:15	134.42	26	110	25.46	SLePcL
271		00:45	134.44	23	100	23.83	SLePcL
272		01:15	134.46	28	90	31.57	SPcLe
273	48.8. 8.	22:15	136.26	14	56	38.97	LeTL
274		22:45	136.28	17	111	20.23	LeTLPc
275		23:15	136.30	31	120	31.29	LeTLPc
276		23:45	136.32	27	91	35.10	LeTLPc
277	48.8. 9.	00:15	136.34	14	60	28.49	LePc
278		00:45	136.36	19	60	36.06	LePc
279		01:15	136.38	22	73	28.92	LePcL
280		21:45	137.20	6	60	17.39	SLeT
281		22:15	137.22	19	96	30.34	SLeTL
282		22:45	137.24	20	120	22.51	SLeTLPc
283		23:15	137.26	21	120	21.87	SLeLPc
284		23:45	137.28	34	120	32.42	SLeLPc
285	48.8.10.	00:15	137.30	37	120	32.67	SLeLPc
286		00:45	137.32	36	120	29.68	SLeLPc
287		01:15	137.34	34	120	26.40	SLeLPc
288		01:45	137.36	3	20	13.28	SLeLPc
289		20:15	138.10	4	20	53.69	LeS
290		20:45	138.12	21	77	58.04	LeSA
291		21:15	138.14	27	128	36.11	LeSALT

No.	Date	T	$l_{1950}$	$\Sigma N_p$	$\Sigma t_p$	$f_z$	Observers
292	48.8.10.	21:45	138.16	40	150	40.71	LeSALT
293		22:15	138.18	34	150	30.98	LeSALT
294		22:45	138.20	37	139	44.94	LeSALT
295	49.8. 2.	22:15	130.26	13	120	15.09	ACeBaI
296		22:45	130.28	13	120	13.58	ACeBaI
297		23:15	130.30	10	92	12.41	ACeBaI
298	49.8. 3.	22:45	131.24	12	105	14.17	ACeBaK
299	49.8. 6.	00:15	133.21	33	120	26.07	ACeKI
300		00:45	133.23	18	120	13.28	ACeKI
301		01:15	133.25	23	120	16.02	ACeKI
302		01:45	133.27	15	72	18.57	ACeKI
303	50.8. 9.	20:45	136.67	6	66	21.93	SJIT
304		21:15	136.69	13	120	21.20	SJIT
305		21:45	136.71	10	120	17.14	SJIT
306		22:15	136.73	14	114	21.50	SJIA
307		22:45	136.75	8	100	10.97	SJIA
308	50.8.10.	23:45	137.75	30	90	39.62	SDJ
309	50.8.11.	00:15	137.77	21	115	18.23	SDJA
310		00:45	137.79	22	78	28.51	SDJ
311		01:15	137.81	21	60	32.15	SD
312		01:45	137.83	7	20	30.64	SD
313		20:15	138.57	7	36	43.14	TDI
314		20:45	138.59	36	90	78.58	TDI
315		21:15	138.61	35	90	67.91	TDI
316		21:45	138.63	34	90	58.92	TDI
317		22:15	138.65	19	90	31.63	ATDI
318		22:45	138.67	57	120	71.18	ADIJ
319		23:15	138.69	36	103	46.73	ADIJ
320		23:45	138.71	16	40	42.72	ADIJ
321	50.8.12.	00:15	138.73	53	101	53.78	ADIJ
322		00:45	138.75	38	60	67.63	DI
323		20:15	139.53	27	54	118.61	TSJ
324		20:45	139.55	48	90	112.02	TSJ
325		21:15	139.57	59	107	91.22	TSJA
326		21:45	139.59	70	90	109.78	TSA
327		22:15	139.61	47	75	78.49	TSA
328		22:45	139.63	18	35	91.42	TJI
329	50.8.13.	00:45	139.71	36	89	43.10	ASD
330		01:15	139.73	30	60	52.13	ASD
331		20:45	140.51	29	125	49.17	ATISD
332		21:15	140.53	44	150	52.49	ATISD
333		21:45	140.55	29	147	29.78	ATSDI
334		22:15	140.57	42	150	39.16	ATSDJ
335		22:45	140.59	38	137	35.58	ATSDJ

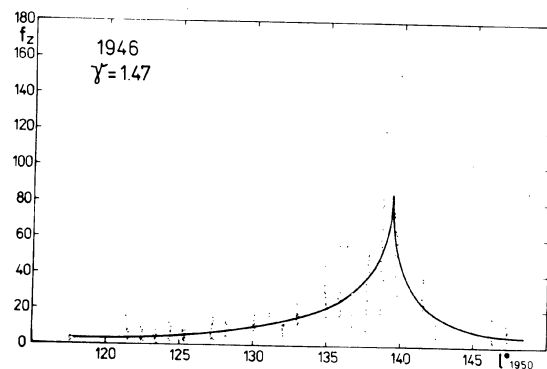
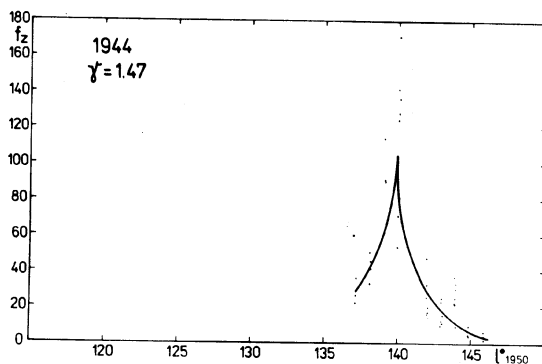
No.	Date	T	$l_{1950}$	$\Sigma N_p$	$\Sigma t_p$	$f_z$	Observers
336	50.8.13.	23:15	140.61	29	120	31.75	AIDJ
337		23:45	140.63	29	120	29.13	AIDJ
338	50.8.14.	00:15	140.65	32	59	59.39	SAID
339		00:45	140.67	27	90	30.97	SID
340	50.8.17.	21:45	144.39	3	16	28.41	ACe
341		22:45	144.43	1	44	2.72	ACe
342	51.7.31.	23:15	127.91	4	85	10.16	QLK
343		23:45	127.93	6	90	13.54	QLK
344	51.8.1.	00:15	127.95	6	95	10.78	QLKFoT
345		00:45	127.97	4	118	5.06	LKFoT
346		01:15	127.99	2	45	6.36	KFoT
347		21:45	128.80	1	159	1.82	FoVrKHaTSu
348		22:15	128.82	1	192	1.34	FoVrKHaTSuL
349		22:45	128.84	9	210	9.73	FoVrKHaTSuL
350		23:15	128.86	13	210	12.77	FoVrKHaTSuL
351		23:45	128.88	10	177	10.67	FoVrKHaTSuL
352	51.8.2.	00:15	128.90	2	122	2.81	FoVrLHaK
353		00:45	128.92	2	60	4.97	FoK
354		01:15	128.94	2	35	8.03	FoK
355	51.8.6.	22:15	133.61	1	90	3.54	HaVrMc
356		22:45	133.63	4	117	8.79	HaVrMcLK
357		23:15	133.65	14	150	21.05	HaVrMcLK
358		23:45	133.67	6	150	8.27	HaVrMcLK
359	51.8.7.	00:15	133.69	12	150	15.49	McKFoVrHa
360		00:45	133.71	4	150	4.82	McKFoVrHa
361		01:45	133.75	6	44	24.03	FoMcVrHa
362		23:15	134.61	4	87	12.11	VrHaMc
363		23:45	134.63	12	150	16.59	VrHaLMcK
364	51.8.8.	00:15	134.65	9	150	11.50	VrHaLMcK
365		00:45	134.67	27	150	32.26	VrHaLMcK
366		01:15	134.69	16	148	18.28	VrHaLMcK
367		01:45	134.71	5	50	17.15	LKHaMc
368	51.8.12.	22:45	139.39	76	120	174.49	VrHaMcI
369		23:15	139.41	44	87	134.57	VrHaMc
370		23:45	139.43	46	90	125.06	VrHaMc
371	51.8.13.	00:15	139.45	60	90	145.14	VrHaMcI
372		00:45	139.47	61	66	186.99	HaMcI
373		01:15	139.49	57	90	120.70	HaMcI
374		01:45	139.51	25	55	82.48	HaMcI
375		23:45	140.39	50	90	130.43	HaMcI
376	51.8.14.	00:15	140.41	69	90	166.53	HaMcI
377		00:45	140.43	72	90	162.36	HaMcI
378		01:15	140.45	36	75	91.74	HaMcI
379		01:45	140.47	5	19	46.50	HaMcI

No.	Date	T	$l_{1950}$	$\Sigma N_p$	$\Sigma t_p$	$f_z$	Observers
380	51.8.12.	22:45	139.39	77	118	154.26	TGLK
381		23:15	139.41	80	90	199.18	TGLK
382		23:45	139.43	63	89	144.93	LTG
383	51.8.13.	00:15	139.45	100	120	152.17	LTGK
384		00:45	139.47	96	120	136.31	LTGK
385		01:15	139.49	109	120	145.82	LTGK
386		01:45	139.51	34	60	87.22	LTGK
387		23:45	140.39	62	120	102.18	LTGK
388	51.8.14.	00:15	140.41	86	120	131.11	LTGK
389		00:45	140.43	96	120	136.76	LTGK
390		01:15	140.45	77	120	103.31	LTGK
391		01:45	140.47	31	42	113.26	LTGK
392	52.7.31.	22:45	128.59	5	112	6.10	StKaPoK
393		23:15	128.61	8	108	9.23	StKaPoK
394		23:45	128.63	7	120	6.65	StKaPoK
395	52.8. 1.	00:15	128.65	5	120	4.40	StKaPoK
396	52.8.13.	21:15	140.99	7	40	34.74	LGKaK
397	52.8.14.	21:15	141.95	7	40	34.57	BjKaGL
398		21:45	141.97	31	147	36.60	BjKaGLK
399	52.8.15.	00:15	142.07	38	150	27.71	BjKaGLK
400		00:45	142.09	22	150	14.97	BjKaGLK
401		01:15	142.11	31	150	19.88	BjKaGLK
402		01:45	142.13	10	60	15.22	BjKaGLK
403		21:15	142.91	6	43	28.70	BjKaGK
404		21:45	142.93	9	118	13.80	BjKaGK
405		22:15	142.95	18	120	24.36	BjKaGK
406		22:45	142.97	11	109	14.84	BjKaGK
407	53.8. 8.	20:15	135.91	3	64	9.07	LBjDeX
408		20:45	135.93	7	120	10.01	LBjDeX
409		21:15	135.95	21	120	26.61	LBjDeX
410		21:45	135.97	13	108	17.08	LBjDeX
411		22:15	135.99	18	120	18.26	LBjDeX
412		22:45	136.01	9	60	16.46	LBjDeX
413		23:45	136.05	29	120	22.16	LBjDeX
414	53.8. 9.	00:15	136.07	26	120	18.38	LBjDeX
415		00:45	136.09	34	120	22.45	LBjDeX
416		01:15	136.11	25	120	15.55	LBjDeX
417		01:45	136.13	13	56	16.92	LBjDeX
418	53.8.10.	20:45	137.85	26	120	37.21	LBjDeX
419		21:15	137.87	47	180	41.27	CeDeGLBjX
420		21:45	137.89	54	145	51.53	CeDeLBjX
421		22:15	137.91	49	120	49.84	LBjDeX
422		22:45	137.93	53	150	40.51	LBjDeXG
423		23:45	137.97	63	99	62.04	LBjDeX



No.	Date	T	$l_{1950}$	$\Sigma N_p$	$\Sigma t_p$	$f_z$	Observers
424	53.8.11.	00:15	137.99	46	150	27.18	LBjDeXG
425		00:45	138.01	61	150	33.64	LBjDeXG
426		01:15	138.03	82	150	42.58	LBjDeXG
427		01:45	138.05	18	66	20.17	LBjDeXGce
428		20:45	138.81	58	135	84.19	BjDeXGce
429		22:15	138.87	90	150	76.10	LBjDeXG
430		22:45	138.89	113	150	86.36	LBjDeXG
431		23:45	138.93	113	135	80.30	LBjDeXG
432	53.8.12.	00:15	138.95	151	150	89.38	LBjDeXG
433		00:45	138.97	166	150	91.72	LBjDeXG
434		01:15	138.99	252	180	108.96	CeDeGLBjX
435		01:45	139.01	65	90	53.58	CeDeGLBjX
436	53.8.14.	20:45	141.69	10	117	16.40	CeDeGLX
437		21:15	141.71	35	150	40.03	CeDeGLX
438		21:45	141.73	28	129	33.97	CeDeGLX
439		22:15	141.75	24	120	28.38	DeGLX
440		22:45	141.77	19	120	20.35	DeGLX
441		23:15	141.79	17	120	16.59	DeGLX
442		23:45	141.81	35	120	31.31	DeGLX
443	53.8.15.	23:15	142.75	25	120	24.40	DeGLX
444		23:45	142.77	23	120	20.62	DeGLX

Table 5 gives for all half-hour intervals the zenith hourly rates  $f_z$  reduced to the same level by applying the annual coefficients for  $\gamma = 1.47$ . Apart from these hourly rates, the table also gives the following data: the ordinal number, the date, the time of the middle of the half-hour interval in UT, the solar longitude  $l_{1950}$ , the total number of meteors,  $\Sigma N_p$ , observed within that interval by all observers, the total net time of observation  $\Sigma t_p$  of all observers within the given interval, and the abbreviations of the individual observers participating in the observations. The date is written for the first half-hour interval of a particular day and applies to all following intervals until the next date is given.



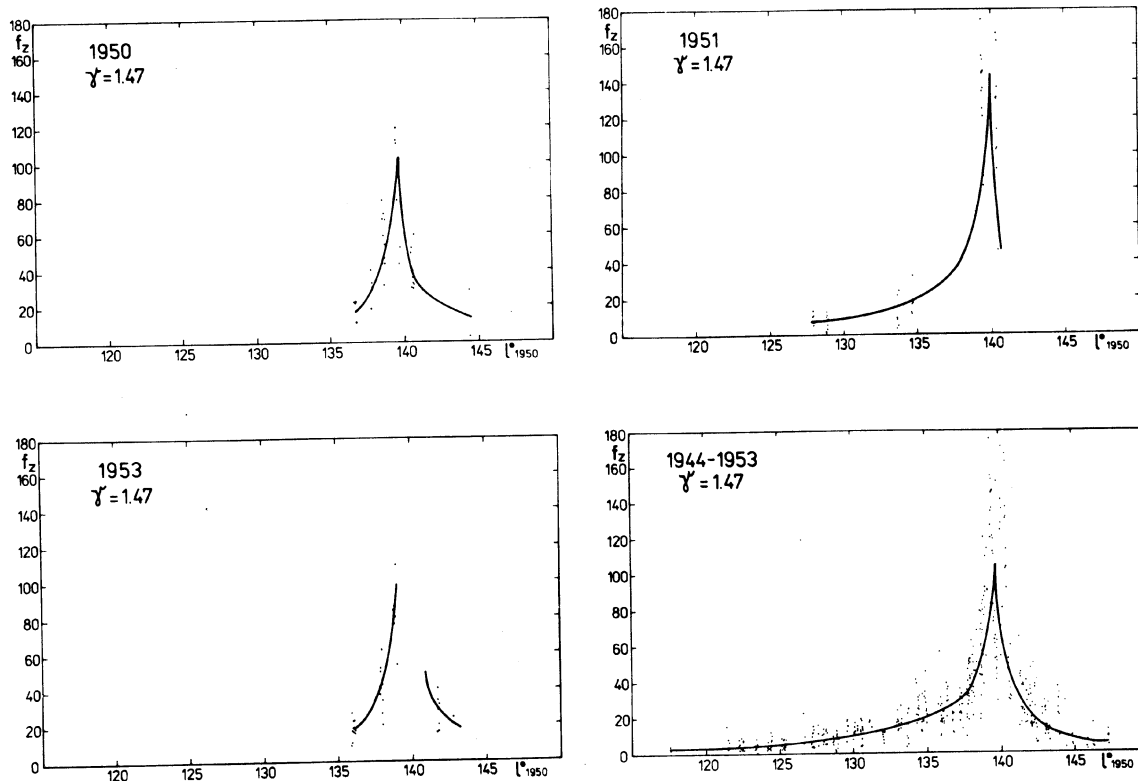


Fig. 2 Hourly rate curves for 1944, 1946, 1950, 1951, 1953 and the mean curve (for  $\gamma = 1.47$ )

Figure 2 gives the curves of hourly rates for  $\gamma = 1.47$  for the years 1944, 1946, 1950, 1951, 1953, together with the summary curve.

#### 4. CONCLUSION

Although the idea that the Perseids display the same activity from year to year has become deep-rooted, several conspicuous deviations have been experienced. For example, in 1921 the hourly rate at the maximum was as high as 250 meteors per hour (Lovell, 1954). In other years the hourly rate was very low, particularly in 1911 and 1912, when only a few meteors were observed per hour; from this Denning (1912) deduced that the shower was vanishing.

The Skalnaté Pleso data also show a considerable difference in the activity of the Perseid shower in different years. Adopting the exponent  $\gamma = 1.47$ , the relative activities (i.e., the inverse values of the annual coefficients) are within the interval  $\langle 0.53; 1.37 \rangle$  and the mean deviation from the average is 0.18.

A definite asymmetry of the Perseid activity before and after the maximum was found, as can be seen from the figures.

The figures also show a number of exceptionally high hourly rates, which deviate from the usual behaviour. On August 12-14, 1951, the maximum was particularly conspicuous as compared with the other years, as well as with the overall trend of the hourly rates in 1951.

A few other examples of high hourly rates, deviating from the general trend, are apparently due to observing a large cluster of meteors within some half-hour intervals.

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