# THE MAGNITUDE DISTRIBUTION OF SPORADIC METEORS AND ITS VARIATIONS

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*Abstract:* The magnitude distribution of sporadic meteors is investigated on the basis of the visual observations of meteors carried out at the Skalnaté Pleso Observatory in the period 1944–1950. The diurnal and seasonal variation of the mean magnitudes of sporadic meteors is studied on the basis of a total of 12,867 magnitude estimates. The results are compared with the mean magnitudes of another 21,996 magnitude estimates, obtained at the Skalnaté Pleso Observatory in the periods of the major showers activities 1944–1953 and studied previously by Kresáková (1966). There is no diurnal variation in the magnitude distribution of the sporadic meteors. The seasonal variation of the magnitude distribution of the sporadic meteors is explained mainly by the influence of uncovered minor showers, as well as by the presence of shower meteors, erroneously taken for the sporadic ones.

*Introduction*

The magnitude distribution of the sporadic meteors differs considerably from that of the shower meteors, the main difference being in various values of the slope of the logarithmically expressed distributions. This fact is firmly established both by optical and radar observations (Watson, 1939; Browne, Bullough, Evans, and Kaiser, 1956; Levin, 1961; Kresáková, 1960, 1966; Kresák, 1964; Millman and McIntosh, 1966).

It follows from this fact that the hourly rates of the sporadic meteors observed, as well as their magnitude distribution might be influenced to a great extent, if the sporadic meteors recorded at a certain period of time include unspecified minor showers, or a large portion of the known shower meteors erroneously taken as the "sporadic" ones. Taken for long period, this effect can considerably influence the observed seasonal variation of the magnitude distribution for the sporadic meteors, e.g. at visual observations, as well as the evaluation of the slope of the magnitude distribution for the shower meteors, e.g. on the basis of radar observations. On the other hand, the analysis of the magnitude distribution together with the hourly rates of meteors can uncover the presence of shower meteors among the "sporadic" meteors recorded.

For the visual observations the magnitude distribution $\varphi(m)$ is usually expressed in the form

$$\varphi(m) = k \cdot r^m, \qquad (1)$$

where $\varphi(m)$ stands for the number of meteors with magnitudes between $m$ and $m+1$, and $k$ is a constant which by definition gives the number of meteors with the magnitude $m = 0$. The coefficient $r$ is the ratio of the increase in the number of meteors if changing the magnitude to the difference $\Delta m = +1.0$, i.e.

$$\log r = \log \varphi(m+1) - \log \varphi(m). \qquad (2)$$

For the radar observations the coefficient $s$ is usually used which is connected with $r$ by the relation

$$s = 1 + 2.5 \log r. \qquad (3)$$

At visual observations the observed magnitude distribution $f(m)$ is influenced by the probability $p(m)$ to observe a meteor of magnitude $m$ by a given observer, i.e.

$$f(m) = k \cdot p(m) \cdot r^m. \qquad (4)$$

The probabilities $p(m)$ were examined by many authors; for the extensive visual data from the Skalnaté Pleso Observatory, which will be the subject for the analysis of the following paper, they were evaluated by Kresáková (1966).

It is possible to determine the slope $r$ not only directly from the actual distribution of the observed magnitudes, but statistically from the mean magnitude $\bar{m}$ as well. For known probabilities

$p(m)$ the mean magnitude $\bar{m}$ is connected with the slope $r$ by the following relation

$$\bar{m} = \frac{r(r-1)^{-2} + \sum\limits_{m=1} m.p(m) \, . \, r^m}{r(r-1)^{-2} + \sum\limits_{m=1} p(m) \, . \, r^m} \, . \qquad (5)$$

For the Skalnaté Pleso visual records the relation between the mean magnitude $\bar{m}$ and the ratio $r$ was examined by Kresáková (1960, 1966), the results are given in Table 8 of her latter paper. The course of this relation is shown in Figure 1.

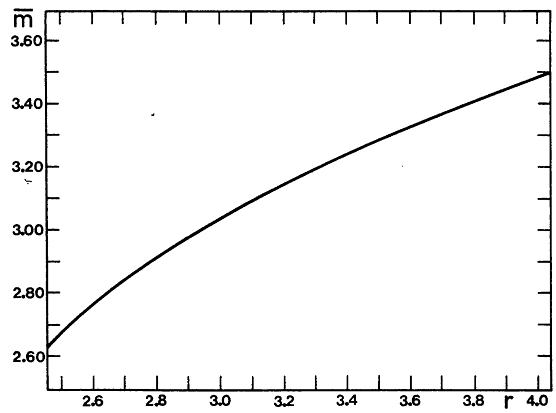


Fig. 1. Relation between the mean magnitude $\bar{m}$ and the ratio $r$.

Kresáková (1966) has shown that there exists a difference between the mean magnitude for shower meteors $\bar{m}_{sh}$ and the one for sporadic meteors $\bar{m}_{sp}$, which for the visual data from the Skalnaté Pleso Observatory has the value

$$\bar{m}_{sh} - \bar{m}_{sp} = -0.43 \pm 0.03. \qquad (6)$$

The corresponding values of the slope $r$ are as follows: $\bar{r}_{sh} = 2.6$ and $\bar{r}_{sp} = 3.5$. It should be noted, however, that the result for sporadic meteors was derived on the basis of records obtained only in the periods of great showers investigated: Lyrids Eta–Aquarids, Delta–Aquarids, Perseids, Orionids, Leonids and Geminids. It does not necessarily represent the whole-year sporadic background.

It is remarkable that the mean magnitude of sporadic meteors, as determined for every single period of the year investigated by Kresáková, shows steady character and does not undergo any visible seasonal variation, being therefore independent on the geocentric velocity. The previous result is in accordance with the Aŝchabad observations (Astapovich, 1958), for which the seasonal changes in the mean magnitude are very small ($\bar{m}$ being 2.75 and 2.95 in the autumn and the spring, respectively), but is in variance with the results of Arizona expedition (Öpik, 1958), showing a strong dependence of the ratio $r$ on the geocentric direction ($r$ being 2.80 for the apparent radiants with the elongations from the Earth's apex $\leq \epsilon_A \leq 60°$, and 3.56 for the elongations $120° \leq \epsilon_A \leq 180°$).

The long-term visual observations of meteors, carried out at the Skalnaté Pleso Observatory in the period 1944–1953, represent a very homogenous set of data which is of great value for the study of the magnitude distributions of sporadic meteors, as well as their possible variations. The aim of the following paper is to examine the magnitude distribution of sporadic meteors on the basis of the observations from the period 1944–1950, excluding short periods of all major showers, which were subjected to the study by Kresáková.

*Observations and Their Errors*

The complete set of the visual meteor data from the Skalnaté Pleso Observatory (latitude 49.2°N, longitude 20.2°, elevation of 1783 m above sea level) obtained in the period 1944–1953, comprise of a total number of about 70,000 individual records of meteor magnitudes, as well as other characteristics of meteors. Until 1947 the observations were carried on virtually every night with favourable weather conditions. Since then preference was given to the periods with the activity of all major meteor showers. As was stated above, the magnitude distribution from all shower periods 1944–1953, both for shower and sporadic meteors, has been analysed by Kresáková (1960, 1966), in total number of 25,885 magnitude records of shower meteors and of 21,996 magnitude records of sporadic meteors.

The following analysis is concerned with the magnitude records of sporadic meteors as recorded in non-shower periods 1944–1950. At each of these periods the team of observers active at one time ranged from 1 to 8. The list of the observers is given in Table 1. The personal errors of the observers have been analysed elsewhere (Kresáková, 1966; Štohl, 1969a; Štohl and Millman, 1973). The probable errors of a magnitude estimate at the centre of the field of view are of the order $\pm 0.30^m$ to $\pm 0.40^m$, and the systematic differences between the estimates of individual observers are in average $\pm 0.20^m$ to $\pm 0.30^m$. The personal coefficients $\nu$, representing the nature of the magnitude distribution re-

*Table 1.* List of the observers

| Observer | Ident. | 1944 | 1945 | 1946 | 1947 | 1948 | 1949 | 1950 | Total |
|---|---|---|---|---|---|---|---|---|---|
| Ambruš. J. | Am | 14 | – | – | – | – | – | – | 14 |
| Bajcár R. | Bj | – | – | – | – | – | 6 | 21 | 27 |
| Bakoš G. | Bk | 14 | – | – | – | – | – | – | 14 |
| Bečvář A. | T | 159 | 769 | 527 | 169 | – | – | – | 1624 |
| Bečvářová K. | Kl | – | 136 | 509 | 74 | – | – | – | 719 |
| Blahová N. | Ba | – | – | – | 76 | – | – | – | 76 |
| Bochníček Z. | Bo | – | – | 41 | – | – | – | – | 41 |
| Ceplecha Z. | Ce | – | – | – | – | 95 | 46 | – | 141 |
| Chmelařová V. | Ch | – | – | – | 20 | – | – | – | 20 |
| Čajda I. | C | – | – | – | – | 10 | 18 | 13 | 41 |
| Drozd L. | D | – | – | – | 59 | – | – | – | 59 |
| Dzubák M. | M | 290 | 679 | 900 | 379 | 78 | – | 79 | 2405 |
| Forgáč M. | F | – | – | – | 9 | 27 | – | – | 36 |
| Hartmanová M. | H | – | 397 | 99 | – | – | – | – | 496 |
| Ivan J. | I | – | – | 27 | – | – | – | – | 27 |
| Jančík T. | J | – | – | – | – | – | – | 37 | 37 |
| Kiss V. | Ki | 23 | 156 | 15 | – | – | – | – | 194 |
| Kresák Ľ. | K | – | – | 991 | 332 | 163 | 59 | – | 1545 |
| Krohová S. | Ko | – | – | 23 | – | – | – | – | 23 |
| Kumurovitz M. | Ku | – | – | – | – | 9 | – | – | 9 |
| Letfus V. | Le | – | – | – | – | 25 | – | – | 25 |
| Lhotský V. | Lt | – | – | 77 | – | – | – | – | 77 |
| Mrkos A. | A | – | 30 | 678 | 421 | 67 | 49 | – | 1245 |
| Olejník Š. | O | 165 | 297 | 17 | 9 | 6 | – | – | 494 |
| Pajdušáková Ľ. | L | 238 | 1055 | 1198 | 313 | 43 | – | 30 | 2877 |
| Píchal Z. | Pi | – | 101 | – | – | – | – | – | 101 |
| Plavec M. | Pc | – | – | – | – | 20 | – | – | 20 |
| Sitár J. | S | – | – | – | 75 | – | – | – | 75 |
| Sobek | Sb | 15 | 40 | – | – | – | – | – | 55 |
| Široký J. | Si | – | – | – | – | – | – | 56 | 56 |
| Uhlár J. | U | 5 | 166 | – | – | – | – | – | 171 |
| Vadovič F. | V | – | – | – | 70 | – | – | – | 70 |
| Valníček B. | Va | – | – | 17 | – | – | – | – | 17 |
| Zapatický J. | Z | 38 | – | – | – | – | – | – | 38 |
| Total | | 961 | 3826 | 5119 | 2006 | 543 | 178 | 236 | 12869 |

corded by the observers (Štohl and Millman, 1973), are close to 1.00 for all observers taken into analysis. For the reason of homogeneity and comparability with the results obtained by Kresáková (1966), the value $\nu \approx 1.00$ for each observer was accepted.

From the data all those observing periods were excluded, for which the cloudiness exceeded 20 per cent, or which were carried out under worsen sky condition, e.g. with the interference of moonlight, twilight or gale.

Table 2 lists all observing periods, arranged according to the months and days for the whole period 1944–1950. For each of the 259 periods there are given the following data: number of the period, date, the mean effective time of the observations $T$ in M.E.T., time of the beginning and the end of the observations, the mean magnitude $\bar{m}$, the total number of magnitude records $N$, from which $\bar{m}$ was obtained, the total number of the observers $k$ participating at the particular observing period, and the identification of the observers as was shown in Table 1. Total of the magnitude records amounts to 12,869. To this number we can add the records of sporadic meteors from the shower periods, as presented in Table 9 of Kresáková's latter paper (1966). For further investigation if given us total of 34,865 records of sporadic meteors.

### *The Variations of the Magnitude Distribution*

The magnitude distribution as well as the mean magnitude of the distribution $\bar{m}$ for each 5-day interval of the year is given in Table 3. The meaning of the values $\bar{m}'$ will be shown later. The values of the mean magnitudes for each interval are presented in Figure 2 by dots with diameters corresponding to the weight of particular means according to the number of records (i.e., 0–49, 50–199, 200–499, 500–999, 1000 and more). The mean magnitudes for sporadic

*Table 2.* List of the observing periods

| No. | Date | *T* | Time | $\bar{m}$ | *N* | *k* | Observ. |
|---|---|---|---|---|---|---|---|
| 1 | 48.01.01 | 21.9 | 21:23 – 22:23 | 3.41 | 22 | 4 | FKMO |
| 2 | 45.01.02 | 18.9 | 17:53 – 19:53 | 3.43 | 54 | 4 | LMOT |
| 3 | 46.01.02 | 21.3 | 20:38 – 21:58 | 3.36 | 30 | 4 | HLMT |
| 4 | 45.01.03 | 20.1 | 19:05 – 21:05 | 3.17 | 64 | 4 | LMOT |
| 5 | 46.01.04 | 20.6 | 19:47 – 21:25 | 3.70 | 53 | 4 | HLMT |
| 6 | 45.01.04 | 21.2 | 20:26 – 21:56 | 3.76 | 37 | 4 | KiLMT |
| 7 | 46.01.05 | 21.6 | 21:08 – 22:08 | 3.04 | 27 | 4 | HLMT |
| 8 | 48.01.06 | 20.8 | 20:12 – 21:27 | 3.31 | 29 | 3 | AKL |
| 9 | 48.01.07 | 20.4 | 20:11 – 20:41 | 2.54 | 13 | 3 | AKL |
| 10 | 46.01.07 | 21.0 | 20:30 – 21:36 | 3.69 | 29 | 4 | HLMT |
| 11 | 46.01.08 | 22.5 | 21:58 – 22:58 | 3.67 | 12 | 3 | KlMT |
| 12 | 46.01.09 | 23.4 | 22:54 – 23:55 | 3.37 | 43 | 4 | AHLM |
| 13 | 47.01.11 | 20.1 | 19:40 – 20:27 | 2.24 | 21 | 4 | ALMT |
| 14 | 47.01.12 | 20.8 | 20:20 – 21:20 | 3.24 | 25 | 4 | ALMT |
| 15 | 45.01.13 | 21.0 | 20:05 – 21:50 | 3.75 | 32 | 5 | LMPiTU |
| 16 | 47.01.14 | 21.1 | 20:37 – 21:37 | 2.97 | 35 | 3 | ALT |
| 17 | 45.01.14 | 22.2 | 21:50 – 22:50 | 3.73 | 20 | 4 | LMOPi |
| 18 | 47.01.16 | 01.8 | 01:15 – 02:15 | 3.25 | 24 | 2 | AL |
| 19 | 47.01.16 | 20.6 | 20:06 – 21:06 | 3.50 | 20 | 3 | ALT |
| 20 | 45.01.16 | 22.0 | 21:33 – 22:33 | 3.55 | 38 | 4 | LMPiT |
| 21 | 47.01.17 | 21.8 | 21:20 – 22:20 | 3.70 | 23 | 3 | ALT |
| 22 | 45.01.17 | 22.6 | 22:21 – 22:56 | 3.20 | 10 | 4 | LMPiT |
| 23 | 45.01.18 | 21.7 | 21:15 – 22:16 | 3.43 | 7 | 4 | LMSbT |
| 24 | 46.01.21 | 20.7 | 20:20 – 21:07 | 3.34 | 15 | 4 | AKlLT |
| 25 | 46.01.22 | 22.1 | 21:41 – 22:25 | 3.24 | 17 | 3 | ALT |
| 26 | 46.01.23 | 21.5 | 21:00 – 22:00 | 3.29 | 34 | 4 | AHLT |
| 27 | 46.01.24 | 22.7 | 21:57 – 23:25 | 3.25 | 40 | 4 | AHLT |
| 28 | 46.01.26 | 20.8 | 20:16 – 21:18 | 3.43 | 30 | 3 | ALT |
| 29 | 46.01.27 | 20.7 | 20:12 – 21:17 | 3.56 | 35 | 5 | AHKlLT |
| 30 | 46.01.28 | 22.6 | 22:07 – 23:07 | 3.20 | 30 | 4 | AHLT |
| 31 | 45.02.01 | 20.5 | 20:01 – 21:01 | 3.29 | 7 | 4 | LMOPi |
| 32 | 46.02.01 | 22.1 | 21:38 – 22:38 | 3.63 | 27 | 4 | HKiKlT |
| 33 | 45.02.03 | 20.5 | 19:47 – 21:17 | 3.06 | 17 | 6 | KiLMOPiT |
| 34 | 46.02.03 | 20.8 | 20:16 – 21:32 | 3.20 | 41 | 4 | AKlLT |
| 35 | 45.02.04 | 20.5 | 19:28 – 21:28 | 3.62 | 29 | 5 | KiLMOT |
| 36 | 45.02.08 | 21.6 | 20:36 – 22:36 | 3.49 | 61 | 8 | KiLMOPiSbTU |
| 37 | 47.02.17 | 20.3 | 19:38 – 20:53 | 3.60 | 15 | 2 | LT |
| 38 | 45.02.17 | 23.5 | 23:00 – 24:00 | 3.90 | 29 | 4 | LMPiU |
| 39 | 45.02.21 | 04.1 | 03:20 – 04:50 | 3.59 | 39 | 4 | LMPiU |
| 40 | 47.02.21 | 20.4 | 19:52 – 21:02 | 3.30 | 23 | 5 | AKlLOT |
| 41 | 46.02.22 | 20.5 | 20:00 – 21:00 | 2.88 | 16 | 3 | ALT |
| 42 | 47.02.24 | 20.9 | 20:12 – 21:37 | 3.37 | 30 | 4 | AKlLT |
| 43 | 46.02.25 | 21.7 | 21:15 – 22:15 | 3.13 | 8 | 3 | ALT |
| 44 | 46.02.26 | 20.5 | 20:04 – 20:57 | 3.55 | 11 | 2 | AT |
| 45 | 47.02.26 | 23.4 | 22:56 – 23:56 | 3.18 | 22 | 2 | AL |
| 46 | 48.02.27 | 20.7 | 20:19 – 20:59 | 3.29 | 14 | 3 | AFKu |
| 47 | 46.02.28 | 20.8 | 20:21 – 21:21 | 2.79 | 24 | 3 | AKlT |
| 48 | 48.02.29 | 23.6 | 23:20 – 23:50 | 3.53 | 19 | 4 | AFKuL |
| 49 | 45.03.01 | 19.7 | 19:14 – 20:14 | 3.90 | 10 | 4 | LMTU |
| 50 | 48.03.02 | 20.6 | 20:07 – 21:07 | 3.32 | 19 | 4 | AFKuL |
| 51 | 48.03.05 | 20.3 | 19:50 – 20:50 | 3.17 | 12 | 3 | AFL |
| 52 | 46.03.06 | 20.7 | 20:12 – 21:13 | 4.00 | 12 | 2 | KlT |
| 53 | 45.03.07 | 20.8 | 20:30 – 21:00 | 3.00 | 7 | 4 | LMPiU |
| 54 | 48.03.12 | 20.3 | 19:48 – 20:48 | 3.33 | 15 | 3 | AFL |
| 55 | 47.03.12 | 22.8 | 22:15 – 23:15 | 3.41 | 17 | 2 | AD |
| 56 | 45.03.13 | 22.9 | 21:49 – 23:53 | 3.19 | 32 | 4 | MPiTU |
| 57 | 45.03.14 | 21.8 | 21:15 – 22:15 | 3.82 | 17 | 3 | MPiU |
| 58 | 45.03.15 | 22.0 | 20:58 – 22:58 | 3.90 | 41 | 6 | KiLMPiTU |
| 59 | 47.03.17 | 22.2 | 21:40 – 22:40 | 3.46 | 13 | 3 | ADL |
| 60 | 46.03.20 | 20.2 | 19:49 – 20:35 | 3.00 | 24 | 3 | AHL |

*Table 2* – continued

| No. | Date | *T* | Time | $\overline{m}$ | *N* | *k* | Observ. |
|---|---|---|---|---|---|---|---|
| 61 | 47.03.20 | 21.3 | 20:43 – 21:50 | 2.71 | 25 | 4 | AKlLT |
| 62 | 47.03.21 | 21.9 | 21:23 – 22:23 | 3.44 | 18 | 4 | AKlLT |
| 63 | 46.03.24 | 20.9 | 20:25 – 21:25 | 3.06 | 11 | 3 | HKiL |
| 64 | 46.03.27 | 21.8 | 21:20 – 22:20 | 3.35 | 31 | 4 | HKlLT |
| 65 | 48.03.28 | 22.2 | 21:43 – 22:36 | 3.67 | 18 | 3 | CMK |
| 66 | 46.03.29 | 21.1 | 20:36 – 21:36 | 3.00 | 21 | 4 | AHLT |
| 67 | 48.03.29 | 22.3 | 21:46 – 22:46 | 3.19 | 27 | 3 | AMK |
| 68 | 46.03.30 | 20.8 | 20:20 – 21:20 | 3.63 | 8 | 3 | KlLT |
| 69 | 48.03.30 | 21.7 | 21:14 – 22:14 | 3.53 | 19 | 3 | AMK |
| 70 | 46.03.31 | 20.5 | 20:05 – 20:55 | 3.62 | 16 | 5 | AHKlLT |
| 71 | 45.04.01 | 20.8 | 20:13 – 21:21 | 3.25 | 16 | 5 | KiLMPiT |
| 72 | 46.04.01 | 21.6 | 21:08 – 22:08 | 2.97 | 36 | 3 | ALT |
| 73 | 46.04.02 | 21.1 | 20:08 – 22:08 | 3.57 | 71 | 5 | AHKlLT |
| 74 | 46.04.03 | 21.5 | 21:00 – 22:00 | 3.42 | 12 | 3 | HLO |
| 75 | 48.04.03 | 22.8 | 22:15 – 23:15 | 3.70 | 23 | 4 | AFKM |
| 76 | 48.04.04 | 22.0 | 21:32 – 22:32 | 3.56 | 16 | 3 | AKM |
| 77 | 46.04.04 | 22.5 | 21:58 – 22:59 | 3.41 | 32 | 3 | AHKl |
| 78 | 46.04.05 | 22.6 | 21:59 – 23:10 | 3.43 | 40 | 4 | AHKlL |
| 79 | 45.04.08 | 21.1 | 20:34 – 21:34 | 3.29 | 24 | 5 | LMPiTU |
| 80 | 45.04.10 | 21.1 | 20:30 – 22:38 | 3.63 | 41 | 4 | KiLTU |
| 81 | 47.04.10 | 21.8 | 21:14 – 22:25 | 3.33 | 9 | 3 | KKlM |
| 82 | 47.04.11 | 22.4 | 21:55 – 22:55 | 3.56 | 18 | 3 | KKlM |
| 83 | 47.04.12 | 22.2 | 21:40 – 22:40 | 3.47 | 45 | 5 | AKKlLM |
| 84 | 47.04.13 | 21.9 | 21:20 – 22:25 | 3.48 | 27 | 3 | KKlM |
| 85 | 47.04.14 | 20.8 | 20:15 – 21:15 | 3.33 | 12 | 3 | KKlM |
| 86 | 47.04.15 | 22.0 | 21:30 – 22:30 | 3.56 | 39 | 6 | AKKlLMT |
| 87 | 46.04.18 | 20.4 | 20:08 – 20:45 | 3.41 | 22 | 5 | AHKlMT |
| 88 | 45.04.30 | 21.2 | 20:40 – 21:45 | 3.33 | 9 | 2 | PiT |
| 89 | 45.05.07 | 22.5 | 21:55 – 23:02 | 3.07 | 14 | 3 | LPiT |
| 90 | 45.05.09 | 22.1 | 21:03 – 23:05 | 3.29 | 19 | 2 | TU |
| 91 | 47.05.12 | 22.8 | 22:21 – 23:13 | 3.24 | 17 | 4 | AKlLT |
| 92 | 45.05.13 | 22.4 | 21:24 – 23:24 | 3.07 | 30 | 3 | LPiT |
| 93 | 47.05.13 | 22.6 | 22:05 – 23:05 | 2.89 | 9 | 2 | LT |
| 94 | 45.05.14 | 22.5 | 22:00 – 23:00 | 3.18 | 28 | 4 | LOPiT |
| 95 | 45.05.15 | 22.4 | 20:55 – 23:57 | 3.23 | 44 | 3 | LPiT |
| 96 | 45.05.16 | 23.1 | 22:07 – 00:07 | 3.79 | 42 | 4 | LPiTU |
| 97 | 45.05.18 | 01.5 | 01:00 – 02:00 | 2.67 | 15 | 4 | LPiTU |
| 98 | 46.05.19 | 22.3 | 21:45 – 22:45 | 3.59 | 17 | 2 | AT |
| 99 | 45.05.20 | 22.2 | 21:39 – 22:39 | 2.21 | 14 | 4 | LPiTU |
| 100 | 46.05.22 | 22.8 | 22:17 – 23:17 | 3.27 | 22 | 3 | ALT |
| 101 | 46.05.30 | 00.3 | 23:54 – 00:51 | 3.00 | 36 | 3 | HLT |
| 102 | 45.05.30 | 22.5 | 22:05 – 22:55 | 2.75 | 20 | 4 | LOPiU |
| 103 | 46.05.31 | 00.2 | 23:45 – 00:40 | 2.71 | 17 | 3 | HKlL |
| 104 | 46.05.31 | 23.1 | 22:29 – 23:42 | 3.29 | 24 | 3 | HKlL |
| 105 | 45.06.02 | 22.9 | 22:02 – 23:44 | 3.19 | 43 | 4 | LPiTU |
| 106 | 45.06.04 | 23.1 | 22:07 – 00:07 | 3.13 | 31 | 3 | LSbT |
| 107 | 45.06.06 | 22.9 | 22:26 – 23:26 | 3.07 | 32 | 5 | LOSbTU |
| 108 | 45.06.07 | 23.6 | 22:17 – 01:15 | 2.98 | 58 | 5 | LOSbTU |
| 109 | 45.06.08 | 22.8 | 22:18 – 23:18 | 2.42 | 19 | 3 | LOSb |
| 110 | 45.06.11 | 23.2 | 22:11 – 00:11 | 2.68 | 34 | 3 | LTU |
| 111 | 45.06.12 | 23.0 | 22:06 – 00:00 | 2.74 | 35 | 3 | LTU |
| 112 | 45.06.14 | 22.9 | 22:22 – 23:22 | 2.85 | 27 | 4 | LOSbT |
| 113 | 45.06.15 | 23.5 | 22:10 – 00:50 | 2.68 | 112 | 5 | LOSbTU |
| 114 | 45.06.18 | 01.2 | 00:47 – 01:36 | 3.43 | 7 | 1 | L |
| 115 | 46.07.01 | 23.9 | 23:22 – 00:27 | 3.36 | 39 | 2 | AL |
| 116 | 46.07.03 | 00.5 | 23:29 – 01:24 | 2.65 | 101 | 4 | AKlLT |
| 117 | 46.07.03 | 23.4 | 22:44 – 00:04 | 3.17 | 60 | 3 | ALVa |
| 118 | 46.07.05 | 00.4 | 00:06 – 00:48 | 3.38 | 26 | 2 | AL |

*Table 2* – continued

| No. | Date | *T* | Time | $\bar{m}$ | *N* | *k* | Observ. |
|---|---|---|---|---|---|---|---|
| 119 | 46.07.06 | 00.7 | 23:58 – 01:21 | 3.23 | 30 | 2 | LKl |
| 120 | 46.07.07 | 01.0 | 00:27 – 01:36 | 3.03 | 36 | 3 | LKlT |
| 121 | 47.07.10 | 22.6 | 21:57 – 23:10 | 2.80 | 40 | 5 | ABaMTV |
| 122 | 45.07.12 | 23.0 | 22:06 – 23:55 | 2.74 | 73 | 5 | HKiLOT |
| 123 | 48.07.13 | 00.7 | 23:55 – 01:25 | 3.03 | 70 | 3 | LeMPc |
| 124 | 48.07.14 | 22.6 | 22:06 – 23:06 | 3.03 | 34 | 3 | LTU |
| 125 | 45.07.16 | 01.2 | 00:42 – 01:42 | 2.91 | 23 | 2 | LM |
| 126 | 50.07.17 | 21.8 | 22:46 – 00:46 | 3.26 | 74 | 5 | JMBiSiV |
| 127 | 47.07.18 | 23.6 | 22:06 – 01:06 | 3.06 | 86 | 7 | BaKKlMSTV |
| 128 | 47.07.20 | 00.2 | 22:20 – 02:00 | 3.03 | 126 | 7 | BaKKlMSTV |
| 129 | 44.07.20 | 22.9 | 21:55 – 23:55 | 3.06 | 158 | 7 | AmBkLMOTZ |
| 130 | 50.07.20 | 23.6 | 22:34 – 00:34 | 3.06 | 90 | 4 | CJMSi |
| 131 | 45.07.21 | 22.2 | 21:37 – 22:37 | 2.50 | 16 | 4 | MOSbT |
| 132 | 44.07.21 | 22.6 | 22:07 – 23:09 | 3.32 | 34 | 5 | AmBkLMT |
| 133 | 50.07.21 | 23.2 | 22:25 – 23:55 | 3.31 | 72 | 3 | MLSi |
| 134 | 47.07.23 | 00.2 | 22:27 – 01:57 | 2.80 | 165 | 5 | BaKMSV |
| 135 | 47.07.23 | 23.8 | 23:35 – 00:05 | 3.55 | 11 | 6 | BaKMSTV |
| 136 | 47.08.21 | 23.1 | 22:35 – 23:35 | 3.08 | 26 | 2 | KM |
| 137 | 47.08.22 | 23.5 | 22:58 – 00:02 | 3.14 | 29 | 4 | KMTV |
| 138 | 49.08.24 | 00.5 | 00:00 – 01:00 | 3.26 | 35 | 3 | CCeK |
| 139 | 47.08.25 | 00.6 | 23:46 – 01:31 | 3.18 | 94 | 4 | KDMV |
| 140 | 48.08.25 | 22.5 | 22:00 – 23:00 | 3.25 | 20 | 2 | CCs |
| 141 | 49.08.26 | 23.3 | 22:34 – 00:00 | 3.02 | 45 | 4 | ACCeK |
| 142 | 44.08.27 | 00.0 | 23:22 – 00:32 | 3.50 | 24 | 2 | LM |
| 143 | 47.08.27 | 00.9 | 00:25 – 01:25 | 2.85 | 64 | 4 | KDMV |
| 144 | 45.08.27 | 20.8 | 20:10 – 21:24 | 3.70 | 43 | 4 | LMTU |
| 145 | 44.08.27 | 23.0 | 21:58 – 23:58 | 3.42 | 55 | 3 | LMT |
| 146 | 46.08.28 | 00.0 | 20:32 – 03:25 | 3.27 | 64 | 3 | KMT |
| 147 | 45.08.28 | 21.2 | 20:19 – 22:04 | 3.65 | 97 | 5 | KiLMOT |
| 148 | 46.08.28 | 22.4 | 21:26 – 23:26 | 3.25 | 98 | 5 | KKlMOT |
| 149 | 44.08.29 | 00.1 | 23:33 – 00:33 | 3.47 | 19 | 2 | LM |
| 150 | 49.08.29 | 00.2 | 23:40 – 00:40 | 3.28 | 40 | 3 | ACeK |
| 151 | 45.08.29 | 21.4 | 20:19 – 22:23 | 3.60 | 96 | 5 | KiLMOT |
| 152 | 46.08.29 | 22.0 | 20:44 – 23:17 | 3.17 | 126 | 5 | KKlLMT |
| 153 | 49.08.29 | 23.3 | 22:45 – 23:45 | 2.95 | 58 | 4 | ABjCeK |
| 154 | 45.08.30 | 21.4 | 20:25 – 22:18 | 3.10 | 52 | 5 | KiLMOT |
| 155 | 46.08.30 | 21.5 | 20:27 – 22:27 | 3.55 | 54 | 3 | AKKl |
| 156 | 46.09.01 | 22.2 | 20:43 – 22:43 | 3.30 | 83 | 4 | KLMT |
| 157 | 46.09.02 | 22.6 | 22:06 – 23:12 | 3.37 | 54 | 3 | KLM |
| 158 | 48.09.03 | 21.5 | 20:50 – 22:15 | 3.89 | 9 | 2 | CeK |
| 159 | 45.09.03 | 22.8 | 22:01 – 23:30 | 3.38 | 50 | 3 | LMT |
| 160 | 46.09.04 | 00.4 | 22:09 – 02:45 | 3.60 | 125 | 4 | KLMT |
| 161 | 45.09.04 | 21.9 | 20:26 – 23:27 | 2.97 | 78 | 4 | LMOT |
| 162 | 46.09.05 | 00.2 | 23:24 – 01:00 | 3.18 | 89 | 4 | AKKlL |
| 163 | 45.09.05 | 21.9 | 20:26 – 23:26 | 3.07 | 138 | 4 | HLMT |
| 164 | 46.09.06 | 00.6 | 23:55 – 01:35 | 3.37 | 111 | 4 | KKlLM |
| 165 | 47.09.06 | 20.8 | 20:20 – 21:20 | 3.36 | 28 | 5 | AKMTCh |
| 166 | 45.09.07 | 00.9 | 20:43 – 03:06 | 3.55 | 177 | 3 | LMT |
| 167 | 46.09.07 | 01.9 | 00:15 – 03:36 | 3.37 | 155 | 4 | KKlLtM |
| 168 | 47.09.07 | 21.0 | 20:20 – 21:35 | 3.29 | 45 | 5 | AKLMCh |
| 169 | 46.09.08 | 02.6 | 01:30 – 03:45 | 2.97 | 126 | 5 | KKlLoLtM |
| 170 | 47.09.08 | 21.3 | 20:45 – 21:45 | 3.20 | 59 | 5 | AKLMCh |
| 171 | 47.09.10 | 21.4 | 20:56 – 21:56 | 2.89 | 46 | 4 | AKMCh |
| 172 | 45.09.10 | 22.1 | 20:50 – 23:22 | 3.10 | 29 | 4 | HLMT |
| 173 | 48.09.11 | 01.5 | 00:47 – 02:12 | 3.43 | 37 | 2 | CeK |
| 174 | 47.09.11 | 21.4 | 20:53 – 21:53 | 3.61 | 38 | 4 | AKMT |
| 175 | 48.09.12 | 01.9 | 01:23 – 02:23 | 3.55 | 38 | 3 | CeKM |
| 176 | 44.09.12 | 20.4 | 19:40 – 21:10 | 3.41 | 44 | 4 | LMOT |
| 177 | 47.09.12 | 21.2 | 20:41 – 21:41 | 3.63 | 49 | 4 | AKLM |
| 178 | 48.09.13 | 02.7 | 01:47 – 03:42 | 3.25 | 63 | 2 | CeK |

*Table 2* – continued

| No. | Date | *T* | Time | $\bar{m}$ | *N* | *k* | Observ. |
|---|---|---|---|---|---|---|---|
| 179 | 47.09.13 | 21.1 | 20:07 – 22:02 | 3.59 | 53 | 5 | AKLMT |
| 180 | 44.09.13 | 21.4 | 20:27 – 22:27 | 2.86 | 69 | 4 | LMOT |
| 181 | 45.09.13 | 23.7 | 20:55 – 02:25 | 3.50 | 169 | 3 | HLM |
| 182 | 48.09.14 | 03.2 | 02:41 – 03:46 | 3.38 | 39 | 2 | CeK |
| 183 | 44.09.14 | 21.1 | 19:51 – 22:15 | 3.22 | 79 | 4 | LMOT |
| 184 | 47.09.14 | 21.8 | 21:17 – 22:14 | 2.96 | 53 | 4 | AKLM |
| 185 | 45.09.15 | 00.9 | 22:25 – 03:21 | 3.47 | 265 | 4 | HLMO |
| 186 | 48.09.15 | 03.2 | 02:48 – 03:30 | 3.14 | 21 | 2 | CeK |
| 187 | 44.09.15 | 21.5 | 20:15 – 22:41 | 3.45 | 76 | 4 | LMOT |
| 188 | 47.09.15 | 21.5 | 21:00 – 22:00 | 3.28 | 58 | 5 | AKLMT |
| 189 | 46.09.16 | 20.2 | 19:27 – 20:56 | 3.42 | 50 | 6 | KKlKoLMT |
| 190 | 44.09.16 | 21.5 | 20:30 – 22:32 | 3.40 | 45 | 3 | LMT |
| 191 | 47.09.16 | 21.7 | 21:11 – 22:15 | 3.24 | 63 | 5 | AKLMT |
| 192 | 45.09.17 | 01.6 | 01:15 – 01:55 | 3.48 | 31 | 3 | HLM |
| 193 | 44.09.17 | 21.0 | 19:55 – 22:03 | 3.33 | 55 | 3 | LMT |
| 194 | 47.09.17 | 21.4 | 20:45 – 22:00 | 3.05 | 84 | 5 | AKLMT |
| 195 | 44.09.18 | 21.3 | 20:35 – 22:05 | 3.32 | 25 | 4 | LMOT |
| 196 | 46.09.18 | 22.2 | 21:35 – 22:52 | 2.92 | 39 | 3 | ALT |
| 197 | 45.09.19 | 03.2 | 02:20 – 03:58 | 3.19 | 78 | 3 | HLM |
| 198 | 47.09.19 | 23.9 | 23:23 – 00:23 | 3.33 | 36 | 3 | AKM |
| 199 | 44.09.20 | 20.2 | 19:15 – 21:15 | 3.41 | 68 | 4 | LMOT |
| 200 | 46.09.20 | 22.0 | 20:06 – 00:58 | 3.48 | 110 | 5 | KKoLMT |
| 201 | 47.09.20 | 23.2 | 19:50 – 02:50 | 3.48 | 58 | 3 | AKL |
| 202 | 46.09.22 | 23.2 | 22:33 – 23:48 | 3.48 | 169 | 5 | KKlLMT |
| 203 | 44.09.23 | 21.0 | 20:00 – 22:00 | 3.13 | 69 | 4 | KiLMO |
| 204 | 46.09.24 | 00.3 | 20:32 – 04:02 | 3.18 | 173 | 5 | KKlKoLM |
| 205 | 46.09.24 | 21.0 | 20:00 – 21:55 | 3.23 | 72 | 5 | KKlLMT |
| 206 | 46.09.25 | 23.6 | 20:13 – 03:03 | 3.20 | 265 | 4 | KKlLM |
| 207 | 47.09.26 | 02.6 | 02:08 – 03:08 | 3.15 | 26 | 2 | AL |
| 208 | 46.09.26 | 23.0 | 20:02 – 01:55 | 3.35 | 212 | 5 | KKlLMT |
| 209 | 47.09.27 | 03.3 | 02:50 – 03:50 | 3.16 | 37 | 2 | AL |
| 210 | 46.09.27 | 22.7 | 20:25 – 00:57 | 3.36 | 191 | 5 | KKiKlLM |
| 211 | 46.09.29 | 23.5 | 19:45 – 03:15 | 3.52 | 292 | 5 | AKKlLM |
| 212 | 46.09.30 | 23.7 | 20:18 – 03:00 | 3.38 | 162 | 4 | KLMT |
| 213 | 46.10.02 | 02.3 | 00:50 – 03:50 | 3.44 | 86 | 2 | KL |
| 214 | 46.10.02 | 21.4 | 21:00 – 21:54 | 3.73 | 15 | 4 | AKLT |
| 215 | 46.10.04 | 00.3 | 21:27 – 03:10 | 3.11 | 105 | 3 | AKlL |
| 216 | 47.10.06 | 20.0 | 19:30 – 20:30 | 3.00 | 20 | 3 | KlOT |
| 217 | 46.10.08 | 03.4 | 02:26 – 04:16 | 3.34 | 93 | 4 | AKKlL |
| 218 | 47.10.08 | 21.1 | 20:35 – 21:35 | 3.55 | 20 | 2 | AL |
| 219 | 45.10.09 | 00.8 | 23:35 – 02:06 | 3.77 | 116 | 3 | KlLM |
| 220 | 47.10.10 | 03.2 | 02:40 – 03:40 | 3.42 | 26 | 2 | AL |
| 221 | 47.10.10 | 20.7 | 20:13 – 21:13 | 3.58 | 40 | 4 | AKlLT |
| 222 | 45.10.13 | 03.4 | 03:03 – 03:50 | 3.48 | 23 | 3 | KlLM |
| 223 | 44.10.13 | 19.5 | 18:30 – 20:31 | 2.39 | 122 | 6 | KiLMOSbT |
| 224 | 46.10.14 | 18.9 | 18:26 – 19:26 | 2.93 | 27 | 4 | AKLT |
| 225 | 45.10.26 | 20.6 | 20:03 – 21:03 | 3.00 | 15 | 4 | KlMT |
| 226 | 45.10.28 | 22.3 | 21:04 – 23:21 | 3.59 | 101 | 4 | HKlOT |
| 227 | 45.10.29 | 21.5 | 20:26 – 22:31 | 3.40 | 68 | 5 | HKiKlOT |
| 228 | 45.10.30 | 20.5 | 19:26 – 21:30 | 3.52 | 71 | 5 | HKiKlOT |
| 229 | 46.10.31 | 04.2 | 03:23 – 05:02 | 2.92 | 71 | 3 | AKKl |
| 230 | 45.11.02 | 01.9 | 00:48 – 03:01 | 3.20 | 103 | 4 | HKiKlT |
| 231 | 45.11.02 | 21.2 | 20:09 – 22:10 | 3.24 | 93 | 5 | HKiKlAT |
| 232 | 47.11.03 | 18.8 | 18:15 – 19:15 | 2.94 | 36 | 3 | AFL |
| 233 | 45.11.04 | 20.5 | 19:31 – 21:30 | 3.15 | 110 | 6 | HKiKlLOT |
| 234 | 46.11.06 | 04.3 | 03:25 – 05:10 | 3.09 | 72 | 3 | AKKl |
| 235 | 45.11.07 | 21.7 | 21:10 – 22:10 | 3.56 | 36 | 3 | KiLT |
| 236 | 45.11.12 | 23.3 | 22:49 – 23:49 | 3.09 | 45 | 3 | HLT |
| 237 | 45.11.22 | 18.4 | 18:00 – 18:50 | 2.83 | 12 | 3 | HLKl |
| 238 | 45.11.23 | 18.7 | 17:48 – 19:30 | 3.60 | 35 | 4 | HKlLO |

*Table 2* – continued

| No. | Date | *T* | Time | $\bar{m}$ | *N* | *k* | Observ. |
|---|---|---|---|---|---|---|---|
| 239 | 46.11.24 | 21.7 | 21:13 – 22:13 | 3.00 | 23 | 2 | LT |
| 240 | 45.11.26 | 21.6 | 20:45 – 22:16 | 3.35 | 34 | 3 | HKlL |
| 241 | 46.11.29 | 04.4 | 03:48 – 04:55 | 3.39 | 38 | 2 | AL |
| 242 | 45.12.01 | 21.6 | 20:35 – 22:35 | 3.41 | 59 | 3 | HKlL |
| 243 | 44.12.02 | 17.9 | 17:36 – 18:12 | 3.43 | 7 | 4 | KiLMO |
| 244 | 45.12.02 | 21.8 | 20:43 – 22:49 | 3.02 | 50 | 3 | HKiL |
| 245 | 46.12.18 | 23.2 | 22:43 – 23:43 | 3.17 | 26 | 4 | lKKlM |
| 246 | 46.12.19 | 23.6 | 21:41 – 01:30 | 3.70 | 158 | 5 | ABolKM |
| 247 | 46.12.20 | 23.1 | 22:09 – 00:09 | 3.34 | 135 | 7 | AlKKlLMT |
| 248 | 45.12.21 | 18.0 | 17:43 – 18:20 | 2.33 | 15 | 4 | HKiMT |
| 249 | 46.12.21 | 22.4 | 21:42 – 23:12 | 3.30 | 105 | 6 | ABolKMT |
| 250 | 45.12.23 | 18.7 | 18:11 – 19:11 | 2.48 | 21 | 5 | HKiMOT |
| 251 | 44.12.24 | 02.4 | 01:56 – 02:56 | 3.25 | 12 | 2 | MU |
| 252 | 45.12.24 | 20.9 | 20:20 – 21:22 | 3.65 | 31 | 4 | HKlMT |
| 253 | 46.12.24 | 22.2 | 21:40 – 22:40 | 3.59 | 12 | 2 | KlT |
| 254 | 45.12.25 | 20.5 | 20:00 – 21:00 | 3.47 | 32 | 4 | HKiMT |
| 255 | 45.12.26 | 20.9 | 20:25 – 21:25 | 2.85 | 20 | 5 | HKiKlMT |
| 256 | 46.12.26 | 22.0 | 21:32 – 22:32 | 2.83 | 17 | 3 | KiKlT |
| 257 | 46.12.27 | 23.2 | 22:45 – 23:45 | 3.04 | 26 | 2 | MT |
| 258 | 46.12.28 | 22.6 | 22:16 – 23:16 | 3.43 | 23 | 3 | KlMT |
| 259 | 45.12.29 | 21.2 | 20:40 – 21:40 | 3.60 | 20 | 6 | HKiKlLMT |

meteors from the shower periods as obtained by Kresáková are denoted by circles. The triangles represent the mean magnitudes of shower meteors for the showers shown in lower part of the Figure 2. The heavy line of the seasonal variation of the mean magnitude of sporadic meteors represent smoothed mean magnitudes $\bar{m}'$ obtained from the values $\bar{m}$ by the formula

$$m' = \frac{\bar{m}_{i-1} \cdot N_{i-1} + 2\bar{m}_i N_i + \bar{m}_{i+1} \cdot N_{i+1}}{N_{i-1} + 2N_i + N_{i+1}} . \quad (7)$$

We can see that there is a considerable variation in the magnitude distribution of sporadic meteors throughout the year. The question arises to what degree it might be influenced by possible

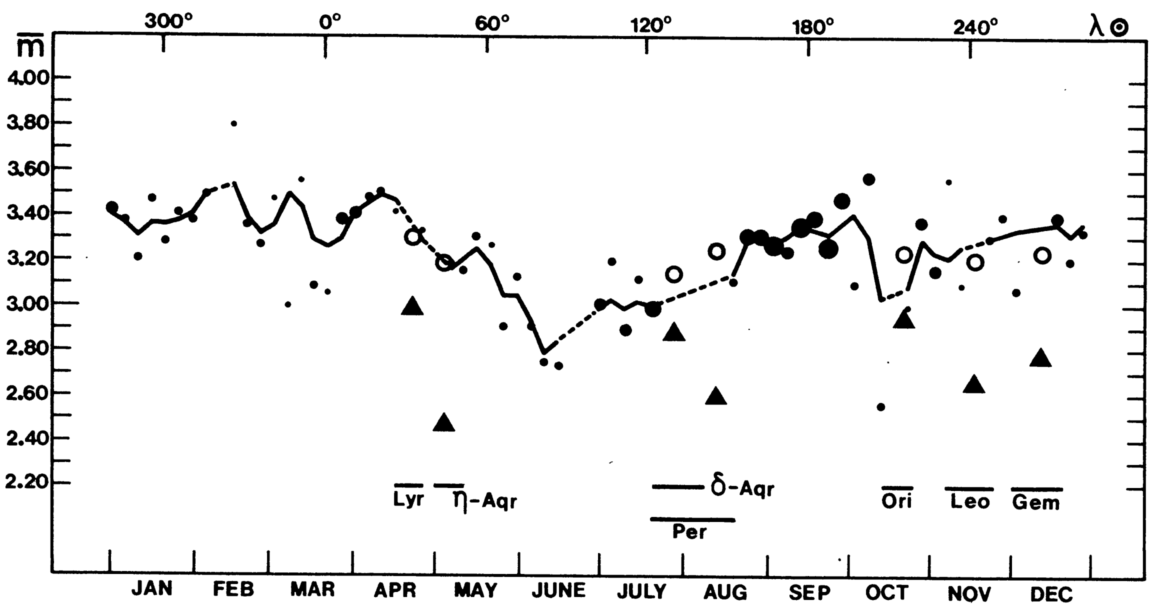


Fig. 2. The mean magnitudes for 5-day intervals.

*Table 3*

| | $\bar{m}$ | $\bar{m}'$ | N |
|---|---|---|---|
| I. 1 | 3.42 | 3.40 | 287 |
| 6 | 3.37 | 3.36 | 126 |
| 11 | 3.21 | 3.31 | 133 |
| 16 | 3.47 | 3.36 | 122 |
| 21 | 3.27 | 3.36 | 106 |
| 26 | 3.41 | 3.37 | 95 |
| 31 | 3.38 | 3.40 | 121 |
| II. 5 | 3.49 | 3.49 | 61 |
| 10 | – | – | – |
| 15 | 3.80 | 3.54 | 44 |
| 20 | 3.36 | 3.39 | 108 |
| 25 | 3.27 | 3.32 | 108 |
| III. 2 | 3.47 | 3.35 | 43 |
| 7 | 3.00 | 3.50 | 7 |
| 12 | 3.56 | 3.44 | 122 |
| 17 | 3.09 | 3.29 | 80 |
| 22 | 3.06 | 3.26 | 11 |
| 27 | 3.38 | 3.39 | 140 |
| IV. 1 | 3.41 | 3.41 | 246 |
| 6 | 3.48 | 3.45 | 74 |
| 11 | 3.50 | 3.49 | 141 |
| 16 | 3.41 | 3.47 | 22 |
| 21 | – | – | – |
| 26 | 3.33 | 3.29 | 9 |
| V. 1 | – | – | – |
| 6 | 3.18 | 3.17 | 33 |
| 11 | 3.16 | 3.20 | 128 |
| 16 | 3.31 | 3.25 | 88 |
| 21 | 3.27 | 3.18 | 22 |
| 26 | 2.91 | 3.04 | 56 |
| 31 | 3.13 | 3.04 | 115 |
| VI. 5 | 2.91 | 2.93 | 109 |
| 10 | 2.75 | 2.79 | 96 |
| 15 | 2.74 | 2.84 | 119 |
| 20 | – | – | – |
| 25 | – | – | – |
| 30 | 3.00 | 2.98 | 200 |
| VII. 5 | 3.20 | 3.02 | 92 |
| 10 | 2.89 | 2.99 | 217 |
| 15 | 3.12 | 3.01 | 183 |
| 20 | 2.98 | 3.00 | 674 |
| 25 | – | – | – |
| 30 | – | – | – |
| VIII. 4 | – | – | – |
| 9 | – | – | – |
| 14 | – | – | – |
| 19 | 3.11 | 3.14 | 55 |
| 24 | 3.31 | 3.30 | 639 |
| 29 | 3.30 | 3.30 | 582 |
| IX. 3 | 3.28 | 3.28 | 1025 |
| 8 | 3.24 | 3.30 | 466 |
| 13 | 3.36 | 3.35 | 1273 |
| 18 | 3.38 | 3.33 | 583 |
| 23 | 3.25 | 3.31 | 1045 |
| 28 | 3.47 | 3.35 | 555 |
| X. 3 | 3.09 | 3.41 | 125 |
| 8 | 3.57 | 3.31 | 295 |
| 13 | 2.56 | 3.03 | 172 |
| 18 | – | – | – |
| 23 | 3.00 | 3.08 | 15 |
| 28 | 3.38 | 3.29 | 311 |
| XI. 2 | 3.16 | 3.23 | 414 |
| 7 | 3.56 | 3.21 | 36 |
| 12 | 3.09 | 3.26 | 45 |
| 17 | – | – | – |
| 22 | 3.30 | 3.30 | 104 |
| 27 | 3.40 | 3.32 | 97 |
| XII. 2 | 3.07 | 3.34 | 57 |
| 7 | – | – | – |
| 12 | – | – | – |
| 17 | 3.40 | 3.36 | 439 |
| 22 | 3.20 | 3.32 | 145 |
| 27 | 3.33 | 3.34 | 69 |

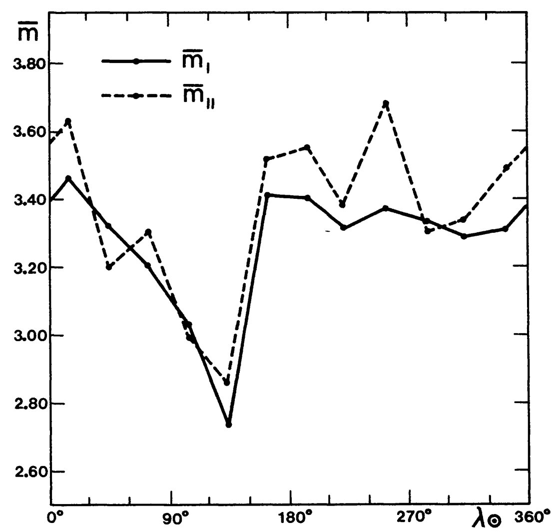


Fig. 3. Seasonal variation of the mean magnitudes for the chosen sets I and II.

changes in atmospheric conditions, e.g. by different atmospheric extinction or by different brightness of the sky. It was shown by Kresáková, that at the high-mountain location of the Skalnaté Pleso Observatory the limiting magnitude is quite steady.

From this point of view it is useful to study in more detail chosen sets of data, to eliminate possible atmospheric influences, as well as influences of less experienced observers. For this purpose the following two special sets of records were chosen from the whole set of data: I. records of meteors with the zenith distances $z \leq 60°$; II. records of meteors with $z \leq 35°$ (Plavec, 1956), recorded by the most experienced observers, namely A, K, L, M, O, and T. In both sets of data sporadic meteors from the shower periods were included, unless the activity of a particular shower did not exceed the sporadic activity. The set I includes a total of 8701 records of magnitudes, the set II amounts to 2002 individual records.

The mean magnitudes $\bar{m}_I$ and $\bar{m}_{II}$, together with the number of records $n_I$ and $n_{II}$ for the respective sets of data I and II are given in Table 4 for every 30-degree interval according to the solar longitude $\lambda_\odot$. We can see (Fig. 3) that the

*Table 4.* The mean magnitudes of the chosen sets of data

| | $\bar{m}_I$ | $\bar{n}_I$ | $\bar{m}_{II}$ | $\bar{n}_{II}$ |
|---|---|---|---|---|
| 0° | 3.46 | 461 | 3.63 | 127 |
| 30 | 3.32 | 39 | 3.20 | 9 |
| 60 | 3.20 | 58 | 3.30 | 22 |
| 90 | 3.02 | 583 | 2.99 | 127 |
| 120 | 2.73 | 123 | 2.86 | 16 |
| 150 | 3.41 | 2871 | 3.52 | 718 |
| 180 | 3.40 | 2004 | 3.55 | 531 |
| 210 | 3.31 | 847 | 3.38 | 185 |
| 240 | 3.37 | 503 | 3.68 | 98 |
| 270 | 3.33 | 726 | 3.30 | 217 |
| 300 | 3.29 | 263 | 3.34 | 77 |
| 330 | 3.37 | 223 | 3.49 | 75 |
| | 3.35 | 8701 | 3.44 | 2202 |

course of the mean magnitudes for both sets of data I and II is almost identical. The low values of the mean magnitudes in both cases occur in the period of May–August (within the solar longitudes $\lambda_\odot \approx 60° \div 150°$), with a minimum at the end of July ($\lambda_\odot \approx 120°$). In the same period occur the low values $\bar{m}$ for the whole set of data (Fig. 2), in this case the minimum $\bar{m}$ being, however, shifted to the middle of June.

We can note that there is a definite tendency for the mean magnitudes $\bar{m}$ from the sets I and II to be lower in the periods of the major showers

*Table 5.* Diurnal variation of the mean magnitudes

| $t$ | $\bar{m}_I$ | $\bar{m}'_I$ | $n_I$ | $\bar{m}'_{II}$ | $\bar{m}_{II}$ | $n_{II}$ |
|---|---|---|---|---|---|---|
| 18 | 2.96 | 3.10 | 81 | 3.28 | 3.43 | 30 |
| 19 | 3.42 | 3.33 | 69 | 4.00 | 3.53 | 16 |
| 20 | 3.35 | 3.38 | 692 | 3.49 | 3.45 | 182 |
| 21 | 3.40 | 3.39 | 1740 | 3.40 | 3.43 | 480 |
| 22 | 3.37 | 3.37 | 1679 | 3.46 | 3.41 | 420 |
| 23 | 3.33 | 3.34 | 1279 | 3.28 | 3.37 | 335 |
| 00 | 3.31 | 3.31 | 988 | 3.49 | 3.43 | 221 |
| 01 | 3.29 | 3.32 | 832 | 3.56 | 3.53 | 195 |
| 02 | 3.44 | 3.36 | 604 | 3.52 | 3.53 | 158 |
| 03 | 3.28 | 3.34 | 528 | 3.52 | 3.51 | 114 |
| 04 | 3.32 | 3.28 | 178 | 3.43 | 3.47 | 35 |
| 05 | 2.76 | 3.18 | 31 | 3.23 | 3.33 | 16 |
| | 3.35 | | 8701 | 3.46 | | 2202 |

activity, which is not so much expressive for the whole set of data. We can conclude therefore that at least a part of shower meteors was erroneously included into the group of sporadic meteors. It is perhaps due to this fact that the mean magnitudes derived in the present analysis for the whole set of sporadic data, as well as for the chosen sets I and II, have a little higher values ($\bar{m} = 3.38$, $\bar{m}_I = 3.35$, $\bar{m}_{II} = 3.44$) in comparison with that for sporadic meteors from the shower periods as obtained by Kresáková ($\bar{m} = 3.24$).

The fact that the mean magnitudes $\bar{m}_{II}$ show considerable variation in the course of the year, for which the weather condition in this case can hardly be responsible, seems to favour the assumption that the whole-year variation of meteors recorded as "sporadic" is influenced by the presence of meteor showers, both major and minor ones. The reason might be in the erroneous inclusion of the shower meteors into the class of sporadic ones, which is not unlikely at visual observations of meteors, especially if the observer have not the radiant of the particular shower in his field of view. To a certain degree it is therefore situation similar to the results derived by Millman and McInotsh (1966) from the radar observations at the Springhill Meteor Observatory (cf. Fig. 3 of their paper), for which shower meteor cannot be distinguished from the sporadic ones because of the observing technique used. For their radar records the peaks in the slope $s$, an equivalent to the ratio $r$ and the mean magnitude $\bar{m}$ for the visual records, however, are much more expressive, which is to be expected, since all shower meteors are included there.

An indirect confirmation of the previous conclusion about the influence of the uncovered shower meteors taken for sporadic ones, gives the analysis of the diurnal variations of the mean magnitudes. Table 5 gives the values of the mean magnitudes $\bar{m}_I$ and $\bar{m}_{II}$ for each hour of the night in L.T. The meaning of the values $\bar{m}'_I$ and $\bar{m}'_{II}$ is as above. We can see (Fig. 4) that there is practically no diurnal variation of the mean magnitudes in the course of the night. We cannot give too much importance to the lower values of the mean magnitudes in the evening hours as well as in the morning hours, because of the low number of records, obtained moreover in the twilight hours. This result agrees both with the Astapovich's observations (Chervyakova, 1956) and the Kresáková's conclusions about the independence of the magnitude distribution on the geocentric velocities of me-

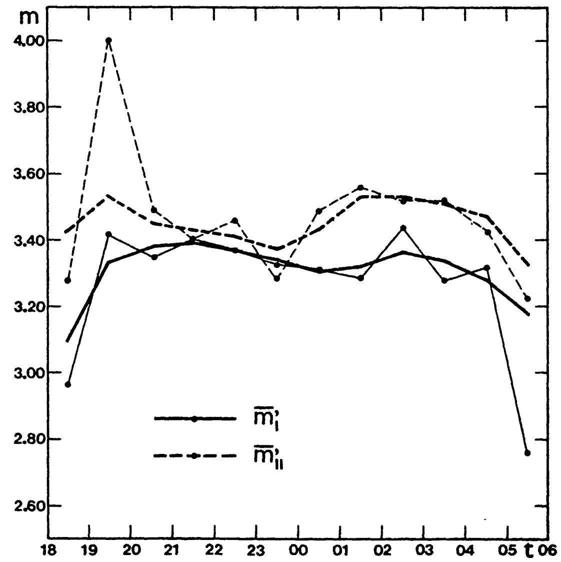


Fig. 4. Diurnal variation of the mean magnitudes for the chosen sets I and II.

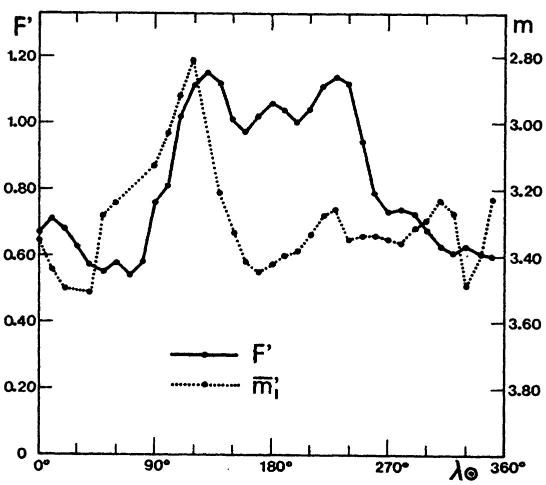


Fig. 5. Seasonal variation of the mean magnitudes and of the hourly rates.

teors, although it is in disagreement with the assumption stated by Levin (1961).

*Discussion of the Seasonal Variations*

In order to verify the assumption about the influence of showers activity on the observed seasonal variation of the magnitude distribution of the recorded sporadic meteors, let us study in more detail the seasonal variations both of the mean magnitudes, as well as of the hourly rates of sporadic meteors. This analysis can give us an idea about the ratio of the shower meteors erroneously counted as the sporadic ones.

Figure 5 shows the seasonal variation both of the smoothed mean magnitudes $\bar{m}'_I$, as well as of the smoothed curve of the relative hourly rates $F'$ of sporadic meteors, as derived by Štohl (1969b) for the visual meteor data of the Skalnaté Pleso Observatory. It is striking that the maximum of the mean brightness of the sporadic meteors occurs in the period of higher hourly rates in July–August ($\lambda_\odot \approx 110^\circ \div 140^\circ$) which suggests a possible influence of the Delta–Aquarid and Perseid meteor showers on the mean magnitude values. It is unlikely that the high values of the hourly rates correspond to an actual increase in the activity of sporadic meteors. The reverse might be said about the broad increase in the rates of sporadic meteors in the autumn months ($\lambda_\odot \approx 170^\circ \div 250^\circ$) which is not accompanied by a raise in the mean brightness of meteors.

Under the assumption of the independence of the magnitude distribution on the geocentric velocity of meteors, as shown above, and taking into account the steady character of the limiting visual magnitude at the Skalnaté Pleso Observatory, we can try to find a way to determine quantitatively the amount of the shower meteors included into the class of sporadic ones. Let us suppose that the increase in the mean brightness of meteors, i.e. the decrease of their mean magnitude, is given by the influence of these "pseudosporadic" meteors. The hourly rates of sporadic meteors $F_{sp}$ recorded as such are then given by the sum of the hourly rates of the real sporadic meteors $F_{rsp}$ and of the shower meteors $F_{psp}$ counted as sporadic ones, i.e.

$$F_{sp} = F_{rsp} + F_{psp}. \tag{8}$$

The observed mean magnitudes $\bar{m}_{sp}$ is then given by the weighed mean of the actually sporadic magnitudes $\bar{m}_{rsp}$ and the "pseudosporadic" magnitudes $\bar{m}_{psp}$, i.e.

$$\bar{m}_{sp} = F_{sp}^{-1} . (F_{rsp} . \bar{m}_{rsp} + F_{psp} . \bar{m}_{psp}). \tag{9}$$

From these relations we can find the ratio of the "pseudosporadic" meteors $F_{psp}$ using the formula

$$F_{psp} = \frac{F_{sp} . (\bar{m}_{sp} - \bar{m}_{rsp})}{(\bar{m}_{psp} - \bar{m}_{rsp})} . \tag{10}$$

The values $F_{sp}$ and $\overline{m}_{sp}$ are given by the observations, the values $\overline{m}_{psp}$ for a certain period can be taken as the mean magnitudes $\overline{m}_{sh}$ of the particular showers. For our data it is necessary to use Kresáková's values of the mean shower magnitudes. For the $\overline{m}_{rsp}$ we can take the grand mean value of the whole-year observations. The results for $F_{psp}$, as well as $F_{rsp}$, are given in Table 6.

It is seen (Fig. 6) that the maximum in the hourly rates of the supposed actually sporadic meteors $F_{rsp}$ in the period of July–August disappear completely. There remains a broad continuous maximum of sporadic hourly rates in the autumn months only. It can be accounted for by the presence of minor showers with the main activity in the fall and winter. This agrees very well with the results obtained for telescopic meteors observed at the Skalnaté Pleso Observatory (Kresáková and Kresák, 1955; Kresák and Kresáková, 1963), which are not influenced by major showers and have their raised activity in the second half of the year.

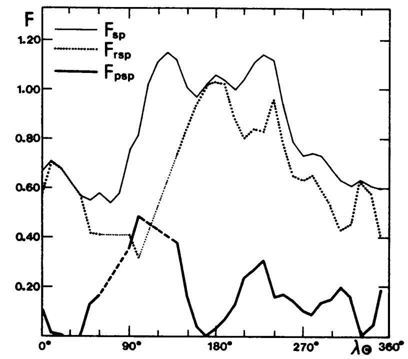


Fig. 6. The hourly rates of the observed sporadic meteors $F_{sp}$ and the calculated values of $F_{rsp}$ and $F_{psp}$.

*Table 6.* Seasonal variation of the mean magnitudes and the hourly rates

| | $F_{sp}$ | $F_{rsp}$ | $F_{psp}$ | $\overline{m}_1$ | Shower | $\overline{m}_{sh}$ |
|---|---|---|---|---|---|---|
| 0° | 0.67 | 0.57 | 0.10 | 3.35 | | |
| 10 | 0.71 | 0.70 | 0.01 | 3.44 | | |
| 20 | 0.68 | 0.68 | 0.00 | 3.50 | Lyr | 3.09 |
| 30 | 0.63 | – | – | – | Lyr | 3.09 |
| 40 | 0.57 | 0.57 | 0.00 | 3.51 | A | 2.57 |
| 50 | 0.55 | 0.42 | 0.13 | 3.28 | | |
| 60 | 0.58 | 0.41 | 0.17 | 3.24 | | |
| 70 | 0.54 | – | – | – | | |
| 80 | 0.58 | – | – | – | | |
| 90 | 0.76 | 0.41 | 0.35 | 3.13 | | |
| 100 | 0.81 | 0.32 | 0.49 | 3.03 | | |
| 110 | 1.02 | – | – | 2.92 | –A | 2.91 |
| 120 | 1.11 | – | – | 2.81 | –A | 2.91 |
| 130 | 1.15 | – | – | – | Per | 2.75 |
| 140 | 1.12 | 0.74 | 0.38 | 3.21 | Per | 2.75 |
| 150 | 1.01 | 0.84 | 0.17 | 3.33 | | |
| 160 | 0.97 | 0.93 | 0.04 | 3.42 | | |
| 170 | 1.02 | 1.02 | 0.00 | 3.45 | | |
| 180 | 1.06 | 1.03 | 0.03 | 3.43 | | |
| 190 | 1.04 | 0.97 | 0.07 | 3.40 | | |
| 200 | 1.00 | 0.87 | 0.13 | 3.39 | Ori | 2.98 |
| 210 | 1.04 | 0.80 | 0.24 | 3.34 | Ori | 2.98 |
| 220 | 1.11 | 0.84 | 0.27 | 3.28 | | |
| 230 | 1.14 | 0.83 | 0.31 | 3.26 | Leo | 2.75 |
| 240 | 1.12 | 0.96 | 0.16 | 3.35 | | |
| 250 | 0.94 | 0.77 | 0.17 | 3.34 | Gem | 2.84 |
| 260 | 0.79 | 0.65 | 0.14 | 3.34 | Gem | 2.84 |
| 270 | 0.73 | 0.63 | 0.10 | 3.35 | | |
| 280 | 0.74 | 0.65 | 0.09 | 3.36 | | |
| 290 | 0.73 | 0.59 | 0.14 | 3.32 | | |
| 300 | 0.68 | 0.53 | 0.15 | 3.30 | | |
| 310 | 0.63 | 0.43 | 0.20 | 3.23 | | |
| 320 | 0.61 | 0.45 | 0.16 | 3.27 | | |
| 330 | 0.63 | 0.63 | 0.00 | 3.49 | | |
| 340 | 0.61 | 0.57 | 0.04 | 3.41 | | |
| 350 | 0.60 | 0.41 | 0.19 | 3.23 | | |

Another way to find out the influence of undistinguished shower meteors on the seasonal variation of the sporadic magnitude distribution is to examine the variations of the hourly rates for meteors with different magnitudes. The difference in the ratio $r$ for the shower meteors and the sporadic ones should be reminded here. We can expect that an increase of the hourly rates of the observed sporadic meteors $F_{sp}$ should reveal itself above all at the brighter meteors.

The relative hourly rates $F_{\leq 2}$ and $F_4$ of the recorded sporadic meteors with the magnitudes $m \leq 2$ and $m = 4$ are given in Table 7, for every 10-degree interval according to the solar longitude $\lambda_{\odot}$. The values $F_{\leq 2}$ and $F_4$ are the smoothed values of the respective hourly rates, calculated as above. It is seen (Fig. 7) that brighter meteors show a tendency to have higher values of the hourly rates in between the periods of the solar longitudes 60° ÷ 80°, 100° ÷ 140°, 210° ÷ 240°, and 250° ÷ 300°. These are the periods of the following prominent showers: the Delta-Aquarids (115° ÷ 136°), the Perseids (118° ÷ 143°), the Orionids (205° ÷ 213°), the Taurids (220° ÷ 245°), the Leonids (232° ÷ 237°), the Geminids (255° ÷ 263°), the Ursids (270°), the Quadrantis (283°), i.e. practically all major showers with the exception of the Lyrids and the Eta–Aquarids. We should note that the magnitude distribution of the Lyrids has the highest value of the ratio $r$, i.e. 3.10, with the lowest corresponding mean brightness $\overline{m}$ = 3.09, while the Eta–Aquarids are observable only in the morning hours shortly before the dawn. In the summertime the difference between the hourly rates of the

*Table 7.* Seasonal variation for sporadic meteors of different brightness

| | $n_2$ | $F_2$ | $F_2$ | $n_4$ | $F_4$ | $F_4$ |
|---|---|---|---|---|---|---|
| 0° | 26 | 0.67 | 0.58 | 29 | 0.56 | 0.64 |
| 10 | 44 | 0.54 | 0.54 | 79 | 0.75 | 0.70 |
| 20 | 24 | 0.38 | 0.46 | 55 | 0.66 | 0.70 |
| 30 | 1 | 0.42 | 0.45 | 3 | 0.94 | 0.70 |
| 40 | 10 | 0.63 | 0.59 | 16 | 0.75 | 0.67 |
| 50 | 38 | 0.58 | 0.74 | 52 | 0.59 | 0.72 |
| 60 | 29 | 1.21 | 0.90 | 35 | 1.09 | 0.80 |
| 70 | 41 | 0.75 | 0.87 | 41 | 0.56 | 0.74 |
| 80 | 49 | 0.88 | 0.86 | 60 | 0.78 | 0.89 |
| 90 | 6 | 1.25 | 1.38 | 16 | 2.50 | 1.20 |
| 100 | 113 | 1.62 | 1.48 | 98 | 1.04 | 1.03 |
| 110 | 204 | 1.33 | 1.38 | 178 | 0.88 | 0.92 |
| 120 | 46 | 1.12 | 1.26 | 49 | 0.91 | 0.88 |
| 130 | – | – | – | – | – | – |
| 140 | 10 | 0.92 | 1.18 | 10 | 0.69 | 1.32 |
| 150 | 236 | 1.17 | 1.13 | 387 | 1.40 | 1.32 |
| 160 | 296 | 1.08 | 1.10 | 432 | 1.19 | 1.25 |
| 170 | 346 | 1.08 | 1.14 | 516 | 1.22 | 1.24 |
| 180 | 240 | 1.37 | 1.25 | 326 | 1.40 | 1.32 |
| 190 | 96 | 1.29 | 1.35 | 151 | 1.53 | 1.44 |
| 200 | 8 | 1.96 | 1.27 | 9 | 1.65 | 1.36 |
| 210 | 89 | 1.12 | 1.22 | 113 | 1.09 | 1.10 |
| 220 | 61 | 1.41 | 1.30 | 62 | 1.06 | 1.07 |
| 230 | 5 | 1.62 | 1.27 | 3 | 0.72 | 1.06 |
| 240 | 27 | 0.83 | 0.90 | 52 | 1.09 | 1.07 |
| 250 | 9 | 0.88 | 1.14 | 12 | 0.91 | 1.02 |
| 260 | 85 | 1.29 | 1.19 | 89 | 1.00 | 0.93 |
| 270 | 39 | 0.79 | 0.95 | 44 | 0.66 | 0.76 |
| 280 | 85 | 0.75 | 0.73 | 99 | 0.66 | 0.63 |
| 290 | 44 | 0.58 | 0.68 | 53 | 0.53 | 0.63 |
| 300 | 42 | 0.75 | 0.65 | 57 | 0.78 | 0.70 |
| 310 | 27 | 0.46 | 0.58 | 54 | 0.69 | 0.76 |
| 320 | 7 | 0.46 | 0.56 | 25 | 1.09 | 0.81 |
| 330 | 39 | 0.67 | 0.63 | 54 | 0.69 | 0.73 |
| 340 | 4 | 0.17 | 0.55 | 20 | 0.56 | 0.61 |
| 350 | 34 | 0.50 | 0.53 | 56 | 0.59 | 0.58 |

bright and the faint meteors to some degree might be influenced even by such diffuse showers as are those of the Iota–Aquarids, the Cygnids, and the Capricornids.

We can make a conclusion that there is definitely a considerable part of undistinguished shower meteors recorded as the sporadic ones which makes a prominent influence both on the seasonal variation of the hourly rates as well as of the mean magnitudes of supposedly sporadic meteors.

On the other hand, there seems to be practically no seasonal variation of the magnitude distribution of the actually sporadic meteors.

*Conclusion*

The analysis of the magnitude distribution of sporadic meteors, recorded at the Skalnaté Pleso Observatory in the period 1944–1950 leads to the following conclusions:

1. there is practically no diurnal variation in the mean magnitudes of sporadic meteors;

2. there exists a definite seasonal variation in the mean magnitudes of meteors recorded as sporadic ones; a further analysis shows, however, that this variation is caused mainly by the influence of uncovered minor showers, as well as by the shower meteors erroneously included into the group of sporadic meteors;

3. the influence of the shower meteors on the magnitude distribution can be uncovered by the analysis of the mean magnitudes and the hourly rates of meteors with different magnitudes;

4. the whole-year mean magnitude of the sporadic meteors on the basis of the Skalnaté Pleso

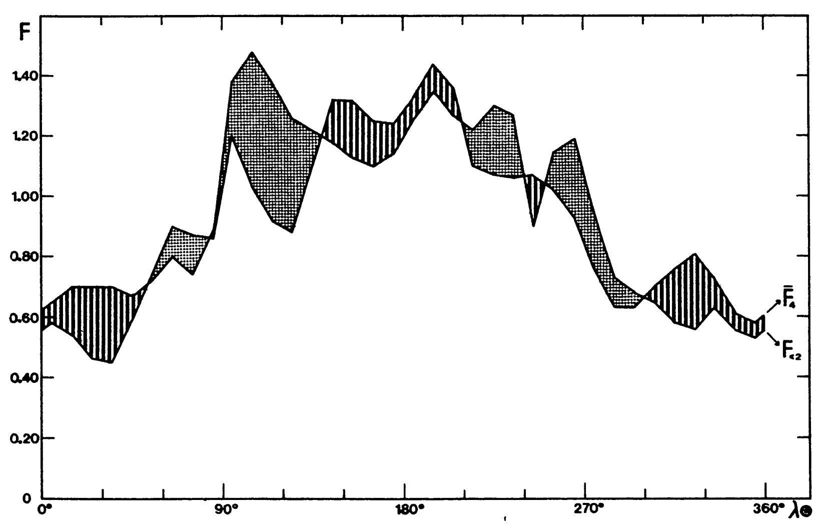


Fig. 7. Seasonal variation of sporadic meteors with magnitudes $m \leq 2$ and $m \geq 4$.

observations has the value $\overline{m} = 3.39$, to which the value of $r = 3.70$ corresponds;

5. for the study of the magnitude distribution of the actually sporadic meteors it seems to be necessary to pay special attention to the activity of the uncovered minor showers.

REFERENCES


ASTOPOVICH, I.S. (1958): Meteornye yavlenia v atmosfere Zemli, 640 pp. Moscow, Gos. izd. fiz.-mat. lit.

BROWNE, I.C., BULLOUGH, K., EVANS, S., and KAISER, T.R. (1956): Proc. Phys. Soc., *B69*, 83.

CHERVYAKOVA, A.F. (1956): Trudy Inst. fiz. i geofiz. AN Turkm. SSR, Vol. 2, 171.

KRESÁK, Ľ. (1964): Bull. Astron. Inst. Czechoslov., *15*, 190.

KRESÁK, Ľ. and KRESÁKOVÁ, M. (1963): Smithsonian Contr. Astrophys., Vol. 7, 253.

KRESÁKOVÁ, M. (1960): Thesis.

KRESÁKOVÁ, M. (1966): Contr. Astron. Observ. Skalnaté Pleso, Vol. 3, 75.

KRESÁKOVÁ, M. and KRESÁK, Ľ. (1955): Contr. Astron. Observ. Skalnaté Pleso, Vol. 1, 40.

LEVIN, B.J. (1961): Physikalische Theorie der Meteore und die meteorische Substanz im Sonnensystem, 313 pp. Berlin, Akademie-Verlag.

MILLMAN, P.M. and McINTOSH, B.A. (1966): Can. J. Phys., *44*, 1593.

ÖPIK, E. (1960): Contr. Armagh Observ., No. 26, 1.

PLAVEC, M. (1956): Meteorické roje, 273 pp. Prague, Publishing House of the Czechoslovak Academy of Sciences.

ŠTOHL, J. (1969a): Contr. Astron. Observ. Skalnaté Pleso, Vol. 4, 25.

ŠTOHL, J. (1969b): Contr. Astron. Observ. Skalnaté Pleso, Vol. 4, 46.

ŠTOHL, J. and MILLMAN, P.M. (1973): Bull. Astron. Inst. Czechoslov., *24*, 321.


## ROZDELENIE MAGNITÚD SPORADICKÝCH METEOROV A JEHO VARIÁCIE


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Súhrn


V práci sa skúma rozdelenie magnitúd sporadických meteorov na základe vizuálnych pozorovaní meteorov, uskutočnených na observatóriu Skalnaté Pleso v rokoch 1944–1950. Denná a ročná variácia stredných magnitúd sporadických meteorov sa skúma na základe celkového počtu 12 867 odhadov magnitúd. Výsledky sa porovnávajú so strednými magnitúdami ďalších 21 996 odhadov magnitúd, získaných na Skalnatom Plese v období činnosti veľkých rojov za roky 1944–1952; tieto údaje už predtým skúmala Kresáková (1966). Nezistila sa nijaká denná variácia v rozdelení magnitúd sporadických meteorov. Ročnú variáciu rozdelenia magnitúd sporadických meteorov možno vysvetliť najmä vplyvom neodlíšených slabých rojov, ako aj prítomnosťou rojových meteorov, chybne zaradených medzi sporadické meteory.


## РАСПРЕДЕЛЕНИЕ ЗВЕЗДНЫХ ВЕЛИЧИН СПОРАДИЧЕСКИХ МЕТЕОРОВ И ЕГО ВАРИАЦИИ


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Резюме


Исследуется распределение звездных величин спорадических метеоров на основе визуальных наблюдений метеоров, полученных в обсерватории Скалнате Плесо в период 1944–1950 гг. Суточная и годичная вариации средних звездных величин спорадических метеоров изучается на основе 12 867 оценок звездных величин. Результаты сравнены со средними звездными величинами 21 996 дальнейших оценок звездных величин, полученных в обсерватории Скалнате Плесо во время активности больших метеорных потоков в период 1944–1953 гг; эти данные были уже прежде подвергнуты анализу Кресаковой (1966). Никакой суточной вариации в распределении звездных величин не оказалось. Годичную вариацию распределения звездных величин спорадических метеоров можно объяснить влиянием невыявленных слабых потоков и присутствием метеоров, принадлежащих к большим потокам, но ошибочно включенных в категорию спорадических метеоров.