TELESCOPIC OBSERVATIONS OF METEORS AT THE TARTU OBSERVATORY

PRELIMINARY RESULTS
DISCUSSED

BY

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1. THE OBSERVATIONS AND THEIR REDUCTION.

Period of observations: from October 6, 1928, to May 4, 1929, and from September 8, 1929, to April 1, 1930. During the summer months meteor observations cannot be made at Tartu because of twilight.

Observers: Messrs. Axel Kipper and Oscar Silde, both assistants of the Tartu Observatory, and the writer.

Instruments and area of observation: two equal telescopes of 60 mm aperture, 60 cm focal length, used with 9.2-fold magnification, diameter of field $6^0.0$. The telescopes were mounted fixedly and directed towards the north pole. By chosing the north pole as object of the watch it is believed that the statistical results gain much in homogeneity. A tube of sheet iron of sufficient diameter piercing the wall permitted of making observations from a warm room; at the lower portion of the tube a narrow prolongation was attached, into which the telescope entered tightly enough to prevent air circulation. By placing the observer into a living room the duration of uninterrupted observations during one night, as well as the efficiency of the observations can be considerably increased; at strong frosts at winter time the observations would otherwise become almost impossible. At cold weather special precautions were taken to prevent the formation of dew on the optical glasses.

During the period from October, 1928, to May, 1929, *simul taneous observations* with the two telescopes were made; at the observatory observed Mr. Kipper, and the writer; Mr. Silde observed at his living quarters, placed at a distance of 1.76 kilometers in 37^0 eastern azimuth from the observatory. During the second period of observations, from September 1929 and later, Mr. Kipper observed alone.

The *reductions* and computations were made chiefly by Miss A. Piiri.

The *magnitudes* are given freed from a subjective systematical error, as far as possible, and reduced to the system of the estimates of the writer.

The *results* relate to the real heights, to the average frequency of meteors of different magnitude, to the variation of the mean horary number with the diurnal rotation of the earth, and to the distribution of the directions of the apparent paths. The distribution of the apparent directions led to the most interesting conclusion that the real distribution of motions of the meteors being far from a uniform one, shows a considerable excess, of objects moving *toward the sun*, the apparent direction being nearly at right angles to the orbit of the earth.

Taking into account the smallness of the field of observation, as well as the relative inaccuracy of the visual observations, radiants of real value could not be determined.

2. HEIGHTS.

The simultaneous observations of the first period gave in all 42 common objects. For the computation of height were used only the meteors whose direction of motion formed an angle with the direction of parallactic displacement exceeding 30^0; 24 such objects were observed. The beginning, or the end of many meteor trails could not be observed, the field of view being limited; therefore only the height of the apparent center of the trail was determined. The average height of the 24 objects was 86 ± 5 (p. e.) kilometers, which corresponds evidently to the middle of the trail, because it may by expected that the limitation by the field of the telescope cuts away with equal probability the beginning, or the end of the trail (or both). The average height, given here and afterwards, is computed from the average parallactic displacement. Table 1 gives the dependence of the observed height upon magnitude. The probable errors are derived from the dispersion of the individual heights.

Table 1.

Average magnitude	6.0	7.6	8.5
Number of objects	7	8	9
Average height and p. e. (km.)	100 ±11	85 ±8	78 ±7

The systematic change of height with magnitude shown by the table, though exceeding the limits of the probable error, may nevertheless be of a subjective character, due perhaps to some kind of subjective selection.

The individual heights range from 45 to 360 kilometers, the corresponding extreme observed values of the parallactic displacements equalling $1^{\circ}.62$ and $0^{\circ}.21$ respectively. The observed dispersion of the individual heights is partly due to observational errors, because the absolute displacement was small; nevertheless, it seemed not advisable to choose a greater distance between the two observing stations, because in this case, with both telescopes directed on the same point in the sky, the percentage of common objects would become too small, and a selection of *high* objects might have resulted.

3. METEOR COUNTS.

The Double-Count method developed by the writer[1]) permits of computing the true number of meteors from the records of two, or more independent observers watching simultaneously the same region of the sky. Without entering into the details, the results are given below. Only the observations on perfectly clear hours were used; recorded clouds, or haze, or low transparency formed a sufficient reason for rejecting the results of the count. The *coefficients of perception* derived for Mr. Kipper from the simultaneous observations of the first period were used for reducing his later observations when he worked alone. Table 2 gives the distribution of the magnitudes, or the so-called Luminosity-Curve of the telescopic meteors; table 3 represents the dependence of the horary number upon the hour of the night.

Table 2.

Total number of meteors on an area of $6^{\circ}.0$ in diameter during 76.2 hours of observation at zenith distance $31^{\circ}.6$ (North Pole of Tartu).

Magnitude	$\leqslant 3.9$	4.0...4.9	5.0...5.9	6.0...6.9	7.0...7.9	8.0...8.9	9.0...10.5
Observed number	0	4	12	19	62	74	133
True number	0	4.9	15.8	24.2	79	140	1570

1) *T. P.* **25.**$_1$; **25.**$_4$, and *A. N.* **219.**$_{93}$.

Table 3.

Results of the counts arranged according to the hour of the night. The hours give Mean Solar Time of the middle of the interval, reckoned from noon. For other circumstances see table 2.

Hour	9h.3	10h.3	11h.3	12h.3	13h.3	14h.3	15h.3
Total *duration* of observations, hours	13.9	18.9	18.4	18.2	16.4	11.6	2.3
a. *Meteors of magnitude 7.9 and brighter.*							
Total *observed* number	21	21	23	26	24	13	3
Mean *true* horary number	**1.96**	**1.40**	**1.58**	**1.86**	**1.92**	**1.37**	**(2.1)**
b. *Meteors of magnitude from 8.0 to 8.9.*							
Total *observed* number	12	14	23	13	15	13	1
Mean *true* horary number	**1.54**	**1.30**	**2.33**	**1.39**	**1.82**	**1.94**	**(1.3)**
c. *Meteors of magnitude 9.0 and fainter.*							
Total *observed* number	22	28	21	37	25	17	3
Mean *true* horary number	**22**	**21**	**16**	**25**	**18**	**19**	**(16)**
d. *a+b. Meteors of magnitude 8.9 and brighter.*							
Mean *true* horary number	**3.50**	**2.70**	**3.91**	**3.25**	**3.74**	**3.31**	**(3.35)**

The real area to which the data of these tables refer must be greater than the area covered by the field of the telescope. Let l be the average length of the meteor trail, d the diameter of the circular field under observation; the effective area for a single observer equals then $S = \frac{\pi d^2}{4} + dl$ . . . (1). The effective length of the visible trail depends upon the apparent brightness of the meteor and upon its speed; this circumstance introduces for telescopic meteors a very complicated factor of selection.

The most interesting feature revealed by table 3 is the fact that the horary number appears to remain constant throughout the night. Rejecting the data of the last column ($15^h.3$) of table 3, we obtain:

	Mean true horary number	
	$m \leqslant 8.9$	$m \geqslant 9.0$
three hours before midnight (9h.3, 10h.3, 11h.3)	3.37	19.7
three hours after midnight (12h.3, 13h.3, 14h.3)	3.43	20.7

The increase in the number after midnight is too small to be of real significance. It is known that observations with the naked eye reveal a noticeable increase of the number of meteors with the advancing hour of the night.

Table 4.

Distribution of the Directions of Telescopic Meteors.

P = angle relative to the Antapex of the earth' orbital motion.

	P	345°... ...14°	15°... ...44°	45°... ...74°	75°... ...104°	105°... ...134°	135°... ...164°	165°... ...194°	195°... ...224°	225°... ...254°	255°... ...284°	285°... ...314°	315°... ...344°
Observed number	before midnight	21	16	18	9	14	11	8	15	33	52	40	31
Observed number	after midnight	31	17	14	10	10	2	2	7	16	30	31	18
	Total	**52**	**33**	**32**	**19**	**24**	**13**	**10**	**22**	**49**	**82**	**71**	**49**
Observed number	*Fall*, mean date 13th October	8	8	5	1	8	4	6	11	12	13	20	12
Observed number	*Winter*, mean date 31th January	15	11	15	7	5	5	3	2	21	29	17	17
Observed number	*Spring*, mean date 27th March	29	14	12	11	11	4	1	9	16	40	34	20

4. STATISTICS OF DIRECTIONS.

Table 4 gives the observed distribution of the directions of motion of the meteors. *P* denotes the angle between the apparent direction of motion of the meteor and the direction toward the antapex of the earth'orbital motion, reckoned in the sense of increasing right ascension. There appears a very marked maximum of frequency toward $P = 270^0$, i. e. toward the sun. The frequency toward the antapex, i. e. toward $P = 0^0$ is unexpectedly small: in the case of a uniform distribution of the motions in space a very marked maximum of frequency toward the antapex should be expected. Though there are several factors, such as zenithal attraction, which may slightly favour directions toward $P = 270^0$ for the North Pole area, these are utterly insufficient to explain the phenomenon. The conclusion is that there seems to exist a marked apparent streaming of meteors approximately toward the sun. This streaming appears to represent a general statistical property of the meteors. Different seasons of the year equally reveal this phenomenon. The theory of this phenomenon will not be treated here; it is hoped to write about this at another time [1]). In table 4 the *observed* number of meteors is given, as it may be supposed that observational selection does not perceptibly depend upon the direction. Observations on nights with clouds, or with haze, rejected for general counts, were here used.

It may be added that the peculiarity in the distribution of directions may be well reconciled with the absence of a periodical change in the horary number during the night, found for the same class of objects and mentioned in section 3.

1) The complicateness of meteor statistics has been pointed out by the writer on several occasions. Compare *A. N.* **235.**$_{265}$; **219.**$_{97}$; **223.**$_{73}$.