RADAR OBSERVATIONS OF THE ORIONID METEOR SHOWER

A. HAJDUK

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

Abstract. Radar meteor echo data obtained by the equipment of the Ondřejov Astronomical Observatory in 1961–1969 during the periods of the Orionid shower activity are presented. The hourly rates of echoes are given in four duration classes. The echo amplitude distribution in the range scale and some other characteristics of the shower and corresponding background are tabulated.

1. *Introduction*

The investigation of the Orionid meteor shower has been included in the observational program of the meteor radar equipment of the Ondřejov Astronomical Observatory. During the period 1961–1969, about 40 000 meteor echoes have been observed consisting of both shower and background activity in a total observation time of 278 hours. Some results deduced from these observations have been published earlier (Hajduk 1968a, 1968b, 1970).

The observations presented here were carried out by the antenna fixed in elevation of 45° and in azimuth of 180°. The reductions of the radar records have been made at the Astronomical Institute of the Slovak Academy of Sciences in Bratislava by measuring the 35 mm film record on a projection screen. Examples of records are in Fig. 1. Each meteor echo is displayed twice on the record, once single and the other time doubled. The distance between the single and the double echo corresponds to 300 kms. The true train distance is given by the single echo. The broad dark trails close to the 0 – and 300 km marks correspond to direct transmitted pulses and ground echoes.

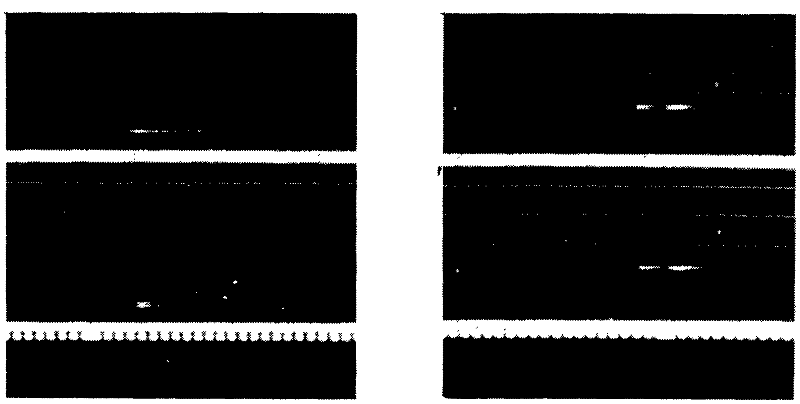

Fig. 1. Examples of radar meteor echo records (Ondřejov 1965). The markers at the bottom indicate 1 sec. intervals, horizontal lines are range markers in 50 km distances.

The apparatus of the Ondřejov meteor radar has been discrebed in detail by Plavcová and Šimek (1960). The main characteristics of the apparatus are as follows: radio frequency 37.5 Mc/s, peak power 18 kw; beam width 52° in the vertical plane between half power points.

The echo characteristics, considered in this article have been read off with the following accuracy: time of appearence in seconds; distance from the station to the nearest 5 km (including range intervals 70–270 km and 340–550 km); echo duration in tenths of a second. Echo amplitudes have been derived from the range-time record in relative units corresponding to a width of 0.05 mm of the echo image measured perpendicularly to the film's motion at its brightest point. The determination of meteor echo amplitudes from the range-time record has been made earlier by means of independent methods (Hajduk 1965b). Most of the data have been reduced by the digital computer ZRA 1 of the Slovak Academy of Sciences.

The summary of observations is given in Tab. 1, where N is the number of echoes on the corresponding date, t the net observing time in hours and minutes, and f the mean hourly rate.

2. *Hourly rates of echoes*

In Tab. 1–5 these observations are listed in detail. Tab. 2 includes observations of all echoes, Tab. 3 echoes with duration $\tau \geq 0.5$ sec., Tab. 4 – echoes with $\tau \geq 1$ sec., and Tab. 5. echoes with $\tau \geq 5$ sec. Some of the records were not suitable

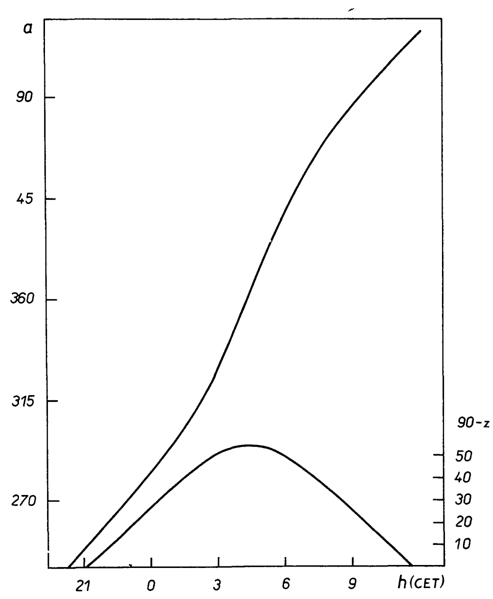

Fig. 2. The position of the Orionid shower mean radiant in dependence on the time (CET) for the geographic itude of the Ondřejov Observatory; A – azimuth, z – zenith distance.

for a precise determination of the echo durations, therefore data on echoes with longer durations are not complete. (Note: the echo frequencies on Oct. 22 and 23, 1966 are questionable due to the extreme noise level interfering at that time). The date of each observation in each Table refers to the nearest time of radiant culmination which takes place at about 04^h20^m CET; this means e.g. that the first observation in Tab. 2 begins at 22:00 CET on Oct. 19, 1961.

There are many factors affecting radar meteor echo duration. The correlation between the visual magnitude and radar echo duration of meteors shows a very wide spread (Lindblad 1956, Millman and Mc Kinley 1956). A comparison of the hourly rates of echoes with different duration, obtained with more sensitive equipment, could therefore help to solve the problem of relative importance of different factors involved.

Comparing the hourly rates of echoes of different duration classes in Tab. 2–5 it was found (Hajduk 1968a) that the percentage of echoes with longer duration decreases symmetrically with decreasing zenith angle of the shower radiant, reaching a maximum at the radiant culmination. The motion of the shower radiant in both azimuth and elevation is shown in Fig. 2, constructed for $\alpha = 93°$, $\delta = 15°$, geographical latitude $\phi = 50°$ and time scale in CET (Central European Time).

3. *The variation of echo amplitude and duration with time*

The question of the activity variations of the Orionid shower in the visual and radar observations since the beginning of this century, including most of the results presented here, has been analysed earlier (Hajduk 1970). Additional data for the study of the mass distribution along and across the stream that could be derived from the distribution of the mean echo amplitude y (in relative units, as mentioned above) is seen in Tab. 6, and the variation of mean log duration τ is in Tab. 7. The meaning of the quantities in Tab. 6 and 7, given for each hour and date, is as follows:

$$y = \Sigma_{i=1}^{n} y_i / n,$$

where only echoes with $y > 4$ rel. units are taken into account;

$$\tau_{\log} = \exp\left(\Sigma_{i=1}^{n} (\ln \tau_i)/n\right)$$

for the same material. The reason of this restrictions is to eliminate the influence of smaller amplitudes, many of which can disappear in the noise disturbances or due to the imperfections of the emulsion. The observational material is made more homogeneous in this way.

Both parameters y and τ show relatively high values in 1961, indicating probably a greater proportion of larger particles in the corresponding part of the stream. On the other hand, the data from 1961 are extended to the day-time hours in which the duration of echoes increases due to the better ionisation conditions in the atmosphere. This is shown in Tab. 7. In comparing the summary data of Tab. 1, it must be taken into account. that there are not always the same periods of the day compared. In spite of this, the difference in values of y and τ are too high in 1961, and we are inclined to explain them by the equipment properties causing change of the echo image.

4. *The variation of the echo amplitude with range*

According to the relations of Kaiser and Closs (1952) and Greenhow (1952), the echo amplitude A corresponding to a meteor train with a constant value of the electron line density $\propto$ depends on the range R as a function of $R^{-3/2}$. This dependence is combined with the effect of the directional diagram G (ϑ, ψ) of the aerial gain in vertical and horizontal planes. Angles ϑ and ψ are measured from the beam axis in both planes. The product $R^{-3/2}$ G (ϑ, ψ) determines the relative sensitivity in the point of given coordinates with respect to the beam axis. The sensitivity contours of the Ondřejov meteor radar for a surface at the height of 100 km have been constructed by the author (Hajduk 1965a).

The real distribution of amplitudes in range can be seen in Tab. 8, containing the number of echoes recorded with a given amplitude (y) and range (R). All echoes from a period of Oct.19.–24.1961 are included in this Table. An increasing number of higher values of amplitudes at the range of 170–175 km in comparison with those at the range of 120–125 km is clearly recognizeable. The former range is occupied mostly by the shower meteors in consequence of the fact, that for a long time the Orionid trains recorded at this range fulfill the condition of specular reflection. The ranges about 120–125 km represent the maximum in the range distribution of sporadic meteors, detected with the highest sensitivity of the apparatus. This effect can be used for the separation of the sporadic background from shower meteors (McKinley and Millman 1949, Hajduk 1968).

The observed amplitude variations with range can be shown in the distribution of amplitudes along the range scale. Tab. 9. has been constructed for a period of Oct. 19–24, 1961, 07:00–12:30 h (CET), when the range distribution of echoes was characteristic for the sporadic distribution (including a small number of shower meteor echoes only). The echo numbers are here divided by the factor d_R, expressing the distance along the spherical surface of the meteor layer between the zenith point of the radar equipment at the height of 100 km and a given meteor train recorded at the distance R from the apparatus. Factor d_R is connected with R by the relation

$$d_R = \frac{\pi}{180} (R_E + H) \cos^{-1} \frac{H^2 + 2R_E H + 2R_E^2 - R^2}{2R_E^2 + 2R_E H}$$

where R_E is Earth's radius and H the atmospheric height of the meteors investigated.

In this way the lines of constant values of N_R/d_R in Tab. 9 define the amplitude-range dependence for a uniform electron line density, irrespectively of its numerical value.

The calculated values of the factor d_R are given in Tab. 10 for H = 100 km and different R. The third and the fourth column of Tab. 10 contain the totals of echo numbers observed at different distances corresponding to the "sporadic" period of Oct. 19–24, 1961, 07:00–12:30 h (CET), the former with, and the later without echoes for which $y < 5$ rel. units. The fifth and the last column give analogous totals for the whole "shower" period of Oct. 19–24, 1961 as represented in Tab. 2.

The dependence of echo amplitude on range can be demonstrated using the mean values of the amplitude of ten brightest meteors observed at different ranges. This is denoted as y_{10} in Tab. 11, deduced from the observations on Oct.20,1961. The arithmetic mean y for all echoes observed at different distances is in the next column of Tab. 11.

For the sake of comparison, the values of mean log duration ($\tau_{\log}$) of the same echoes are given in Tab. 11, where

$$\tau_{\log} = \exp \sum_{i=1}^{n} (\ln \tau_i)/n$$

The corresponding echo numbers in the last column in Tab. 11 conclude these data.

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Table 1

	N	t	$\bar{f}$
1961 Oct. 20	2983	$13^h\ 27^m$	221.8
21	1979	10 54	181.6
22	2245	12 41	177.0
23	706	06 04	116.4
24	1363	13 31	100.9
29	348	03 14	107.6
1962 Oct. 8	347	02 47	124.7
9	550	03 30	157.1
10	468	03 08	149.4
16	894	08 04	110.8
17	1088	07 09	152.2
19	1293	11 08	116.1
20	1369	08 07	168.7
21	1253	09 50	127.4
23	1128	08 38	130.7
24	1075	08 12	131.1
27	821	08 57	91.7
1963 Oct. 22	1885	10 32	179.0
23	1441	10 53	132.4
1964 Oct. 16	206	02 45	74.9
1965 Oct. 14	435	02 46	157.2
15	373	02 11	170.8
19	326	02 34	127.0

	N	t	$\bar{f}$
1965 Oct. 20	494	$05^h\ 00^m$	98.8
21	328	03 56	83.4
22	365	03 26	106.3
Nov. 3	305	02 54	105.2
4	666	03 02	219.6
1966 Oct. 19	232	01 46	131.3
20	761	05 42	133.5
21	957	04 49	198.7
22	807	03 36	224.2
23	834	03 50	217.2
24	1259	05 01	251.0
1967 Oct. 20	857	07 30	114.3
21	797	08 42	91.6
22	1221	08 35	142.3
23	1064	08 31	124.9
24	507	07 13	70.3
Nov. 4	919	08 26	109.0
5	135	01 19	102.5
1968 Oct. 19	859	02 34	334.1
20	743	02 38	282.4
1969 Oct. 21	203	03 56	51.7
22	404	04 41	86.3

Table 2
Hourly rates of all echoes

1961 Oct.	22	23	00	01	02	03	04	05	06	07	08	09	10	11
20	141	190	195	220	249	261	278	329	324	292	174	160	156	106
21	127	180	168	217	265	299				212	181	156	99	91
22	90	109	200	235	233	258	226	229	183	179	169	138	86	61
23	120	123	130	137	124						117	64		
24	94	129	107	123	149	145	100	85	86	129	79	70	67	51
29											113	115	101	94
1962 Oct.														
8					104	144	122							
9				140	177	176	117							
10				82	138	169	177							
16			86	98	107	147	133	114	128	97	74			
17			122	154	147	146	169	167	185	129				
19			128	148	160	136	132	122	137	93	96	86	68	76
20			114	167	202	175	192	187	197	145	126			
21		85	123	129	104	166	122	145	137	144	115	150		
23			114	132	130	147	133	142	125	122	128			
24			124	96	169	145	140	119	132	137	114			
27			105	78	65	119	76	111	90	113	91	62		
1963 Oct.														
22	110	148	167	169	126	218	225	242	197	189	183	134		
23	117	117	144	113	175	135	149	246	143	143	130	105	77	

Continuation Table 2

1964 Oct.	22	23	00	01	02	03	04	05	06	07	08	09	10	11
16											97	83	50	
1965 Oct.														
14					145	170	156							
15					151	181	204							
19							178	137	94	108				
20						201	132	84	83	69	60			
21					164	127	74	71						
22								213	104	89	53			
Nov. 3					120	52	148							
4					206	220	240	105						
1966 Oct.														
19							197	133						
20							105	120	150	121	151	153	78	
21								237	232	192	183	152	168	
22								215:	150:	196	235	194	168	
23								253:	191:	144:	227:	234		
24								312	320	289	188	143		
1967 Oct.														
20					109	167	144	138	140	107	83	57	36	
21	79	96	91	101	105	89	116	101	104	75				
1967 Oct.														
22	85	124	148	126	171	164	148	160	202	150				
23	133	152	115	129	136	140	106	116	101					
24	89	85				80	74	81	83	68	60			
Nov. 4		95	76	146	116	136	116	108	99	95				
5		102	108											
1968 Oct.														
19								443:	372:	348:				
20							264:	290:	399:	345:				
1969 Oct.														
21							90			224	174	147	91	71
22								123	103	136	129	80	35	

Table 3
Hourly rates of echoes with duration $\tau \geq 0.5$ sec.

	22	23	00	01	02	03	04	05	06	07	08	09	10	11
1961 Oct.														
20	71	90	100	112	128	137	114	127	131	125	74	72	75	55
21	66	86	81	86	82	107				78	73	83	50	48
22	42	57	99	100	82	130	96	108	71	78	72	60	46	34
23	65	56	56	52	54						35	31		
24	43	68	47	59	60	57	33	27	30	39	32	33	24	24
1962 Oct.														
17			43	37	54	38	35	38	52	31				
19			48	70	45	42	37	34	47	24	34	28	27	28
20			44	62	94	68	65	70	56	39	30			
21		38	51	39	32	47	33	36	43	52	34	90		
23			55	65	45	53	39	36	35	43				
24			49	32	62	55	47	38	46	42	39			
27			4	1	1	0	4	2	1	2	5	4		
1963 Oct.														
22	45	56	45	43	33	60	51	66	60	58	49	43		
23	48	40	46	37	47	29	35	52	48	32	31	37	20	
1965 Oct.														
14					52	44	36							
15					46	50	40							
19							19	22	10	36				
20						45	25	11	10	14				
21					40	25	12	12						
22								41	19	16	12			
Nov.														
3					30	11	39							
4					59	45	47	15						

Table 4
Hourly rates of echoes with duration $\tau \geq 1.0$ sec.

	22	23	00	01	02	03	04	05	06	07	08	09	10	11
1961 Oct.														
20	29	31	34	42	37	38	27	28	28	31	17	32	35	28
21	21	20	29	28	26	27				26	19	30	23	21
22	12	20	29	32	35	45	27	26	23	27	16	22	15	5
23	20	16	20	21	23						14	19		
24	8	30	21	14	23	28	11	11	9	13	13	9	11	12
1962 Oct.														
17			24	15	22	5	3	9	26	13				
19			18	21	15	11	16	6	12	9	14	8	9	8
20			12	14	25	25	15	20	14	6	10			
21		14	10	13	15	11	12	11	14	16	11	30		
23			16	18	14	17	12	6	9	14				
24			13	13	25	17	16	5	19	11	11			
27			22	8	13	7	8	4	7	10	10	6		

Continuation Table 4

1963 Oct.	22	23	00	01	02	03	04	05	06	07	08	09	10	11
22	21	23	19	15	16	29	27	25	13	24	15	14		
23	15	17	9	7	18	6	12	16	15	14	11	13	8	
1965 Oct.														
14					17	19	4							
15					9	15	12							
19							8	11	3	0				
20						18	12	5	4	8				
21					20	8	8	7	2					
22								13	7	9	6			
Nov.														
3					9	6	16							
4					22	15	11	0						
1966 Oct.														
19							13	4						
20							5	10	8	11	5	6	6	
21								15	20	12	11	10	19	
22								8:	11:	8	10	15	24	
23								14:	7:	10:	23:	14		
24								16	18	13	14	17		
1967 Oct.														
20					21	18	12	9	8		3	4	7	
21	8	20	6	13	10	14	4	3	5	15				
22	12	23	11	13	8	15	14	10	5	8				
23	17	18	8	12	12	7	1	8	9					
24	11	10				3	3	2	5	4	5			
1968 Oct.														
19								38:	29:	24:				
20							35:	27:	24:	20:				
1969 Oct.														
21							10	8		14	12	14	9	0
22								5	2	11	17	6	0	

Table 5
Hourly rates of echoes with duration $\tau \geq 5.0$ sec.

1961 Oct.	22	23	00	01	02	03	04	05	06	07	08	09	10	11
20	0	5	4	2	3	12	5	12	5	7	4	11	13	13
21	2	4	4	1	3	10				10	8	10	5	2
22	9	6	11	13	7	13	9	10	11	10	7	7	4	3
23	0	4	4	4	6						5	5		
24	2	5	1	3	4	10	5	5	3	6	2	2	3	4

Continuation Table 5

1962 Oct.	22	23	00	01	02	03	04	05	06	07	08	09	10	11
17			2	5	8	2	1	2	8	4				
19			1	6	2	2	6	4	4	2	2	0	3	0
20			1	2	7	7	2	5	6	3	2			
21		4	4	1	8	5	5	5	4	9	2	0		
23			5	4	4	6	5	2	2	3	5			
24			1	4	7	6	4	1	6	5	6			
27			4	1	1	0	4	2	1	2	5	4		
1963 Oct.														
22	3	9	5	7	4	6	7	11	2	12	9	12		
23	6	4	2	3	7	3	3	14	4	7	5	7	3	
1965 Oct.														
14					5	3	0							
15					1	6	4							
19							2	4	0	0				
20						4	3	1	1	3				
21					8	1	3	3	2					
22								5	4	3	4			
Nov.														
3					2	1	4							
4					3	3	0	0						

Table 6
Variation of mean echo amplitude with time

1961 Oct.	22	23	00	01	02	03	04	05	06	07	08	09	10	11
20	7.5	6.6	7.3	6.8	7.0	7.3	6.9	6.7	7.2	7.2	7.3	7.4	6.9	7.1
21	7.4	7.5	7.7	7.0	6.5	6.9				6.6	6.8	6.6	6.9	6.4
22	6.5	7.2	6.6	6.4	6.1	6.7	6.8	6.9	6.6	7.4	6.9	6.8	7.0	6.7
23	5.8	6.2	6.0	6.1	5.9						5.8	5.8		
24	5.7	6.6	6.5	6.3	6.2	5.8	6.3	6.3	6.4	6.2	6.3	7.1	5.8	4.7
1962 Oct.														
17			5.5	5.8	5.5	5.5	5.4	5.2	5.3	5.1				
19			5.8	6.1	5.5	5.3	5.3	5.4	5.6	5.4	5.4	5.3	5.7	5.4
20			5.7	5.5	6.0	5.7	5.3	5.7	5.8	5.7	5.2			
21		6.1	5.7	5.5	5.2	5.3	5.2	5.2	5.0	5.3	5.4	5.0		
23			6.2	6.3	5.5	5.8	5.6	5.6	5.5	5.5	5.3			
24			5.6	5.3	5.6	5.7	5.7	5.7	5.7	5.6	5.4			
27			5.7	5.1	5.5	5.4	5.2	5.2	5.4	5.4	5.1	4.9		
1963 Oct.														
22	5.4	5.3	5.2	6.2	5.1	5.4	6.2	6.2	5.7	5.5	5.4	5.2		
23	5.0	5.5	5.3	5.7	5.3	5.1	5.1	5.6	5.4	5.2	5.0	5.1	4.9	

Continuation Table 6

1965 Oct.	22	23	00	01	02	03	04	05	06	07	08	09	10	11
14					5.6	5.5	5.6							
15					5.8	5.8	5.7							
19							5.3	5.4	5.4	6.4				
20						5.8	5.6	5.8	4.9	5.2				
21					5.6	5.4	5.5	5.5	4.8					
22								5.3	5.3	5.3	5.4			
Nov.														
3					5.8	5.7	5.8							
4					6.1	5.6	5.7	7.2						

Table 7
Variation of mean log duration with time

1961 Oct.	22	23	00	01	02	03	04	05	06	07	08	09	10	11
20	0.47	0.46	0.51	0.51	0.51	0.56	0.44	0.42	0.42	0.42	0.49	0.62	0.64	0.14
21	0.54	0.47	0.54	0.41	0.39	0.41				0.41	0.46	0.60	0.54	0.55
22	0.50	0.54	0.53	0.50	0.42	0.51	0.47	0.50	0.52	0.55	0.49	0.51	0.58	0.57
23	0.51	0.46	0.47	0.44	0.56						0.42	0.68		
24	0.46	0.58	0.48	0.45	0.45	0.51	0.45	0.44	0.42	0.42	0.47	0.52	0.48	0.62
1962 Oct.														
17			0.39	0.30	0.36	0.36	0.25	0.27	0.39	0.34				
19			0.37	0.46	0.31	0.33	0.39	0.36	0.40	0.36	0.45	0.39	0.44	0.39
20			0.42	0.36	0.45	0.43	0.37	0.38	0.36	0.32	0.31			
21		0.47	0.42	0.21	0.46	0.35	0.34	0.35	0.37	0.43	0.35	0.64		
23			0.47	0.35	0.42	0.39	0.35	0.33	0.35	0.44				
24			0.38	0.44	0.43	0.41	0.39	0.35	0.42	0.37	0.38			
27			0.44	0.41	0.45	0.32	0.35	0.32	0.35	0.33	0.37	0.39		
1963 Oct.														
22	0.46	0.49	0.38	0.38	0.36	0.39	0.28	0.30	0.36	0.43	0.40	0.45		
23	0.41	0.44	0.37	0.40	0.37	0.33	0.34	0.38	0.38	0.37	0.35	0.45	0.35	
1965 Oct.														
14					0.38	0.32	0.30							
15					0.33	0.33	0.30							
19							0.29	0.30	0.29	0.33				
20						0.34	0.31	0.27	0.24	0.33				
21					0.36	0.27	0.32	0.34	0.22					
22								0.25	0.26	0.29	0.37			
Nov.														
3					0.32	0.31	0.34							
4					0.33	0.29	0.27	0.20						

Table 8

Amplitude – range distribution of echoes

R \ y	3	4	5	6	7	8	9	10	11	12	13	14	>14
75		4	2	5	3								
80	3	7	6	5	2	2	1						
85	2	3	7	3	8			2	1				
90	6	13	6	8	3	5	1	1	2			1	
95	5	27	19	26	9	12	4	3	3	4		1	1
100	5	28	36	23	12	10	2	2	3	7	4		10
105	3	37	24	30	23	12	6	12	4	3			1
110	17	39	42	47	20	15	7	12	9	4	4		4
115	19	72	50	46	20	21	17	14	5	4	5	1	5
120	22	81	77	73	26	31	13	15	12	5	2	1	5
125	22	69	50	58	24	29	12	19	6	6	2	2	3
130	28	102	72	64	28	26	18	20	20	9	3	3	3
135	19	56	59	49	29	27	10	11	8	12	5	3	5
140	19	77	53	58	29	31	20	30	14	14	6	6	8
145	13	96	57	52	22	28	15	14	12	7	3	2	6
150	9	67	52	47	29	22	13	19	13	10	2	1	9
155	12	47	38	30	24	26	12	15	5	3	1	2	
160	16	76	43	48	24	21	19	17	11	11	2	3	4
165	13	54	48	41	28	30	13	21	12	16	4	2	6
170	14	75	60	51	30	31	20	31	18	13	4	2	9
175	11	63	43	41	26	25	16	16	24	8	3	4	6
180	13	56	39	42	29	14	12	8	16	13	6	5	3
185	11	34	29	25	19	13	5	5	11	9	5	4	3
190	11	52	46	25	20	21	11	13	13	12	5	3	2
195	9	42	39	33	18	26	3	7	3	6	1	2	1
200	6	28	23	38	19	10	3	6	4	12	3	2	7
205	2	17	19	30	20	19	5	5	6	3	2	1	
210	5	34	21	27	19	13	8	6	5	4	3	3	4
215	2	40	28	33	17	19	6	7	5	7	3		
220	6	44	30	28	15	15	3	4	10	3	2	4	
225	2	20	16	16	14	5	5	3	6	3	1		1
230	3	24	34	16	15	11	5	8	1	2	2	1	2
235	1	20	15	19	10	2	3	3	3	5		1	1
240	2	22	25	13	12	8	12	4	5	3	2		2
245	2	17	18	7	14	5	2	2	1	1			2
250		9	8	3	4	7	2	6	2	6		1	1
255		10	9	7	7	6	1	3	3	2	1		2
260	1	11	20	16	12	11	1	4	3	1	1		
265		5	10	12	7	7	1	7	2		3	1	
270	1	6	9	10	3	4	1	6	1	2			
340	1	5	1	1	3	1	1	1	1	1			
345	2	5	2	5	5		3	2		1			

R \ y	3	4	5	6	7	8	9	10	11	12	13	14	>14
350	1	18	13	10	7	9	3	3	2	3		2	2
355	3	10	9	11	5	3		2					
360	7	32	17	21	12	4	3	2	4	1		1	1
365	7	25	12	15	10	6	5	1	1				
370	9	37	15	14	9	11	1	5	2	4			
375	5	34	16	25	8	6	6	4	4				
380	13	36	29	18	13	7	5	1	2	2	1	2	1
385	6	20	22	14	9	9	2	1	1	2	1		2
390	7	23	14	14	5	5	2	3	1				
395	2	18	12	7	2	2							
400	5	29	17	13	9	12	4	3	3	6	1	1	3
405	7	29	20	10	3	7	1	5					
410	10	24	20	15	3	6	5	1	3	2	2		
415	9	24	11	8	3	4	1	1	1	4	1	1	
420	15	32	22	11	6	4	3	5		3		1	1
425	8	29	8	6	1	4	1	5		2			
430	11	36	11	14	4	4		3				1	
435	7	16	8	8	4	2	1	2		1			
440	6	14	12	11	6	3		1					
445	1	9	6	4	3	3							
450	2	13	8	6	3	1	2	1					
455	4	8	11	6	3	2			1	1			
460	6	22	12	9	1			2					
465	4	17	3	4	1	2	2						
470	4	12	10	11	4	1							
475	5	11	7	3	1	2			1				
480	12	23	12	10	1	3							
485	1	11	6	10	1				1				
490	6	5	4	4	2	1	1						
495		5	2						1				
500	1	5	4	3	2	1	1						
505	3	7	6		1					1			
510	2	13	5	4									
515	1	4	7	5		1							
520	1	7	3	4	1			1					
525	1	4	2	4	4								
530	1	4	4	4	2	1							
535	1	2	2	4		1							
540		4		1	1								
545		1	1										
550		3	1	1	1	1							

Table 9

Amplitude – range distribution of reduced echo numbers

R \ y	3	4	5	6	7	8	9	10	11	12	13	14	>14
105	6.2	58.8	34.1	58.8	24.8	9.3	9.3	21.7	6.2	3.1			
110	2.2	26.0	39.0	51.9	15.2	10.8	6.5	15.2	8.7	4.3	6.5		4.4
115	7.0	62.9	35.0	35.0	15.7	17.5	14.0	10.5	5.2	1.7	7.0		1.7
120	1.5	38.9	28.4	25.4	16.4	22.4	9.0	12.0	4.5	3.0	3.0	1.5	3.0
125	6.6	41.0	17.2	19.8	9.3	18.5	9.3	11.9	2.6	5.3		1.3	2.6
130	7.2	27.5	28.7	20.3	10.8	9.6	13.1	6.0	8.4	6.0		2.4	2.4
135	5.5	10.9	8.8	14.2	7.7	6.6	4.4	5.5	4.4	5.5		2.2	2.2
140	2.0	22.3	11.1	15.2	11.1	9.1	3.0	12.2	4.1	3.0			2.1
145	0.9	17.0	17.0	9.5	4.7	6.6	0.9	2.8	2.8	3.8	0.9		0.9
150	2.7	16.0	10.6	9.8	5.3	2.7	2.7	5.3	3.5	1.8			
155	1.7	18.4	4.2	7.5	6.7	4.2	1.7	2.5	0.8		0.8		
160		12.7	7.1	5.6	2.4	4.0	3.2	2.4		1.6			1.6
165	1.5	11.3	6.0	6.0	9.8	5.3	3.8	1.5	2.3	2.3			0.8

Continuation Table 9

R \ y	3	4	5	6	7	8	9	10	11	12	13	14	>14
170	2.2	7.2	5.8	4.3	2.2	7.2	2.9	3.6	2.2	3.6	0.7		0.7
175	1.4	11.7	6.2	6.9	1.4	2.1	4.1	1.4	2.8	0.7	0.7		0.7
180	0.7	4.6	5.3	4.0	3.3	2.7	3.3	0.7	1.3	1.3	1.3	0.7	0.7
185	0.6	3.8	3.8	3.2	1.3	2.5		1.9		0.6	0.6		0.6
190	1.2	8.0	7.4	1.2	1.8	1.8	1.2	0.6	2.5	1.2	0.6	0.6	
195	1.8	7.1	5.9	5.9	2.4	2.4	0.6	0.6		0.6			0.6
200		2.9	4.0	4.0	1.1	0.6		0.6	1.1	0.6	0.6		1.8
205	0.6	2.2	2.8	3.3	2.2	3.9	1.1	0.6				0.6	
210	1.1	4.3	3.8	4.8	1.6	1.6	0.5	0.5		1.6	0.5		
215		5.7	3.1	5.2	1.6	1.0	1.6	2.6	1.0	0.5	0.5		
220	1.0	5.1	2.5	5.1	0.5	0.5	0.5		0.5			1.0	
225		3.0	2.0	1.0	1.0		1.5	1.0					
230	1.0	1.9	3.4	3.4	0.5	1.0		1.0	0.5	0.5	0.5	0.5	
235		2.8	0.9	2.8	0.5	0.5		0.5	0.9	1.4			
240		1.4	3.6	0.5	2.3	1.4	2.7	0.9	0.9		0.5		0.5
245	0.4	2.2	0.4	0.9	2.2	1.8	0.9	0.9					0.4
250		1.3	0.9	0.4	0.4	1.3	0.4	0.9		0.4			
255		0.4	0.8	0.8	2.1	0.8		0.4			0.4		
260		0.4	0.4	1.2	0.4	0.8	0.4	0.4	0.8	0.4			
265		0.4	1.2	0.8	0.8	1.2		0.8	0.8		0.8		
270	0.4	0.8	1.2		0.8			1.2		0.4			
340	0.3	1.2	0.3	0.3	0.3	0.3	0.3	0.3		0.3			
345	0.3		0.9	0.3	0.6		0.3	0.3					
350		2.7	1.8	0.6	0.3	2.1	0.3	0.3		0.6			0.3
355		0.9	0.6	1.7	0.3	0.9							
360	0.3	3.4	2.0	2.6	1.4	0.6	0.3		0.6				
365	0.3	3.1	1.4	1.4	1.1	0.6	0.3						
370	1.1	5.6	2.2	1.1	0.6	1.4		0.3		0.6			
375	0.5	3.6	1.6	3.0	0.8	0.5	0.5		0.3				
380	1.4	3.2	2.4	1.9	1.1	0.8	0.8	0.3	0.3			0.3	
385		1.3	2.1	2.7	0.5	1.1	0.3		0.3	0.5			0.3
390	0.3	2.4	1.3	1.3	0.3		0.3	0.3	0.3				
395		2.1	1.6	1.0	0.3	0.5							
400	0.8	3.6	1.3	2.0	0.8	1.8	0.3	0.3	0.5	0.5	0.5		0.3
405	0.8	2.8	2.3	1.5	0.3	0.3		0.8					
410	0.7	2.0	1.7	1.2	0.2	0.7	0.7		0.2	0.2			
415	0.2	2.2	0.5	0.5	0.2	0.5		0.2	0.2	0.2		0.2	
420	0.5	2.9	2.9	0.7	0.5	1.0	0.2	0.7		0.5		0.2	0.2
425	0.5	4.1	0.7	0.2		0.7		0.7		0.2			
430	0.7	3.6	1.4	1.9	0.5	0.7		0.5					
435	0.9	1.4	0.9	0.7	0.2		0.2						
440		1.2	0.9	1.4	0.7	0.2		0.2					
445		0.9	0.7	0.2	0.2	0.2							
450		1.6	0.9	0.2	0.5	0.2	0.2						
455	0.2	0.9	0.7	0.7	0.4				0.2				
460	0.7	1.8	0.7	0.7				0.4					
465	0.2	1.1				0.2							
470	0.2	1.5	0.4	0.9	0.4								
475		1.1	0.6	0.4		0.2			0.2				
480	0.2	1.5	1.3	0.2		0.4							
485		0.8	0.6	1.7	0.2				0.2				
490		0.2	0.2	0.4									
495		0.6	0.4										
500		0.4	0.2	0.4									
505		0.2	0.6		0.2					0.2			
510		0.4	0.8	0.4									
515			0.4			0.2							
520		0.2	0.2	0.4									
525		0.2	0.4	0.2									
530		0.6	0.2	0.2	0.4								
535				0.6									
540		0.6	0.2										
545		0.2	0.2										

Table 10

R	$d_{R,H=100\text{ km}}$	$N_{sp,y\geq3}$	$N_{sp,y\geq5}$	$N_{sb,y\geq3}$	$N_{sb,y\geq5}$
75		5	5	14	10
80		12	8	26	16
85		13	10	26	21
90		19	14	46	27
95		65	49	114	82
100	0	69	56	142	109
105	35	75	54	155	115
110	48	88	75	220	164
115	58	122	82	279	188
120	67	113	86	363	260
125	76	110	74	302	211
130	83	119	90	396	266
135	91	71	56	293	218
140	99	94	70	365	269
145	106	72	53	327	218
150	113	68	47	293	217
155	119	58	34	215	156
160	125	51	35	295	203
165	131	67	50	288	221
170	137	59	46	358	269
175	143	58	39	286	212
180	150	45	37	256	187
185	156	30	23	173	128
190	162	46	31	234	171
195	168	47	32	190	139
200	174	30	25	161	127
205	180	31	26	129	110
210	185	38	28	152	113
215	191	44	33	167	125
220	197	33	21	164	114
225	203	18	12	92	70
230	208	29	23	124	97
235	214	22	16	83	62
240	219	32	29	110	86
245	225	23	17	71	52
250	230	14	11	49	40
255	235	14	13	51	41
260	241	13	12	81	69
265	247	17	16	55	50
270	252	12	9	43	36
340	326	12	7	16	10
345	332	9	8	25	18
350	337	30	21	73	54
355	343	15	12	43	30
360	348	39	26	105	66
365	354	29	17	82	50
370	359	46	22	107	61
375	364	40	25	108	69
380	369	46	29	130	81
385	374	34	29	89	63
390	379	24	14	74	44
395	384	21	13	43	23
400	390	49	32	106	72
405	395	34	20	82	46
410	400	32	21	91	57
415	405	21	11	68	35
420	410	43	29	103	56
425	415	30	11	64	27
430	420	39	21	84	37
435	426	19	9	49	26
440	431	20	15	53	33
445	436	10	6	26	16
450	441	16	9	36	21
455	447	14	9	36	24
460	452	19	8	52	24
465	457	7	1	33	12
470	462	16	8	42	26
475	467	12	7	30	14
480	472	17	9	61	26
485	477	17	13	30	18
490	483	4	3	23	12
495	488	5	2	8	3
500	503	5	3	17	11
505	508	6	5	18	8
510	513	8	6	24	9
515	518	3	3	18	13
520	523	4	3	17	9
525	529	4	4	15	10
530	534	7	4	16	11
535	539	3	9	10	7
540	544	4	1	6	2
545	549	2	1	2	1
550	555	–	–	7	4

Table 11

R	$\bar{y}_{10}$	$\bar{y}$	$r_{\log}$	N
75	3.1	5.2	0.27	5
80	4.4	4.3	3.04	11
85	5.3	4.7	0.90	13
90	7.0	5.0	0.52	22
95	10.8	6.6	0.53	45
100	12.2	6.8	0.49	40
105	10.8	6.6	0.63	44
110	11.6	6.1	0.45	82
115	14.8	6.4	0.48	91
120	12.7	5.8	0.43	130
125	11.3	6.0	0.44	102
130	11.9	5.9	0.38	112
135	13.7	6.7	0.49	97
140	13.7	6.6	0.43	129
145	11.9	6.5	0.45	96
150	13.8	7.2	0.46	92
155	10.8	6,6	0.46	71
160	13.3	6.4	0.42	105
165	13.6	7.2	0.51	97
170	13.7	7.3	0.47	94
175	13.7	7.3	0.44	83
180	12.5	6.7	0.44	75
185	13.0	7.1	0.54	62
190	12.3	7.0	0.53	84
195	11.1	6.5	0.54	71
200	12.5	6.7	0.56	53
205	11.2	6.9	0.55	49
210	13.2	7.8	0.66	45
215	10.1	6.5	0.47	49

Continuation Table 11

R	$\bar{y}_{10}$	$\bar{y}$	τ log	N
220	11.7	7.2	0.53	41
225	10.4	6.9	0.50	36
230	11.2	7.0	0.54	39
235	10.1	7.1	0.44	24
240	10.1	6.7	0.47	38
245	7.7	6.1	0.57	21
250	7.8	7.2	0.77	12
255	9.2	7.5	0.58	17
260	9.1	6.8	0.43	27
265	8.0	7.4	0.57	23
270	8.8	7.1	0.50	18
340		6.0	4.02	6
345	5.8	6.0	3.05	8
350	9.9	6.3	0.71	31
355	6.2	5.4	0.40	15
360	10.1	6.4	0.53	39
365	8.8	5.7	0.70	26
370	8.7	5.7	0.49	39
375	6.6	5.3	0.34	23
380	7.2	5.1	0.39	37
385	8.5	6.1	0.59	23
390	6.7	5.0	0.66	23
395	3.9	4.8	0.25	9
400	9.7	6.5	0.66	28
405	6.2	5.3	0.53	18
410	8.0	5.6	0.42	30
415	7.1	5.0	0.38	23
420	9.6	5.2	0.40	35
425	6.3	5.4	0.58	14
430	6.4	4.5	0.38	28
435	6.2	5.3	0.47	15
440	6.4	5.4	0.34	17
445	5.0	4.6	0.34	12
450	5.5	5.1	0.35	12
455	4.4	5.3	0.41	8
460	5.2	4.6	0.33	16
465	3.9	3.9	0.28	10
470		5.3	0.63	6
475	5.2	5.3	0.54	10
480	6.0	4.5	0.33	24
485	4.5	5.4	0.82	8
490	3.5	4.7	0.42	7
495		4.0	0.20	1
500	4.2	6.3	0.88	6
505		3.7	0.48	3
510	3.2	4.1	0.75	7
515		4.5	0.82	2
520		4.0	0.24	2
525		5.3	0.41	3
530		6.7	0.69	3
535		4.0	0.20	1
540		7.0	1.40	1
545		5.0	0.40	1
550	2.6	6.3	0.34	3

RADAROVÉ POZOROVANIE METEORICKÉHO ROJA ORIONÍD

A. HAJDUK

Astronomický ústav Slovenskej akadémie vied, Bratislava, Československo

Resumé

Práca obsahuje údaje z pozorovaní meteorického roja Orioníd v rokoch 1961–1969 získané meteorickým radarom Astronomického ústavu ČSAV v Ondřejove a spracované na Oddelení medziplanetárnej hmoty Astronomického ústavu SAV v Bratislave. Prehľad pozorovaní obsahuje Tab. 1. V Tab. 2–5 sú uvedené hodinové frekvencie radarových ozvien pre štyri kategórie stôp meteorov s trvaniami $\tau > 0{,}0$ sek., $\tau \geq 0{,}5$ sek., $\tau \geq 1{,}0$ sek. a $\tau \geq 5{,}0$ sek. Výsledky ukazujú úbytok ozvien s trvaním nad 0,5 sek. a nad 1,0 sek. v okolí kulminácie radiantu. (Obr. 2 znázorňuje pohyb radiantu roja v azimute a výške.) Vysvetlenie možno hľadať v závislosti trvania stopy od uhla vstupu meteoroidu do atmosféry (Hajduk 1968a). Závislosť charakteristík ozvien od výšky radiantu vidieť aj z Tab. 6 a 7, obsahujúcich zmeny priemerného trvania a priemernej amplitúdy ozvien v priebehu pozorovaní. Vaššie hodnoty týchto charakteristík ozvien v r. 1961 nemusia byť nevyhnutne dôsledkom zmeny funkcie jasnosti, resp. excesu väčších častíc v zodpovedajúcej oblasti meteorického prúdu. Niektoré náznaky svedčia skôr o zmene zobrazovacích vlastností aparatúry. Pri použití súborov ozvien z vhodne volených intervalov vzdialeností, ktoré v dôsledku kombinácie podmienky kolmosti odrazu so smerovou citlivosťou aparatúry charakterizujú raz prevažne rojové meteory, inokedy prevažne meteory sporadické, dá sa zistiť pomer rojových meteorov k meteorom sporadickým (Tab. 8–9). Ten však závisí ešte aj od zvoleného rozpatia slnečných dĺžok, dennej doby a metódy pozorovania (Hajduk 1968b). Pre pozorované kategórie meteorov sa určila strmosť funkcie jasnosti $\kappa_{sb} = 2{,}7$ pre rojové meteory a $\kappa_{sp} = 3{,}6$ pre meteory sporadické ktorá je vo veľmi dobrej zhode s výsledkami optických pozorovaní (Kresáková 1966) a potvrdzuje relatívny nedostatok drobných čiastočiek v meteorických rojoch. Priebeh frekvencií ozvien pozdĺž dráhy Zeme i v jednotlivých návratoch potvrdzuje filamentárny charakter štruktúry prúdu Orioníd, odvodený z rozsiahlych pozorovaní tohto roja od začiatku nášho storočia (Hajduk 1970).

РАДИОЛОКАЦИОННЫЕ НАБЛЮДЕНИЕ МЕТЕОРНОГО ПОТОКА ОРИОНИД

А. ХАЙДУК

Астрономический институт Словацкой Академии Наук, Братислава, Чехословакия

Резюме

Предлагаются данные наблюдений метеорного потока Орионид полученные в течение 1961–1969 гг., аппаратурой Астрономической обсерватории ЧСАН в Ондржееве и обработанные в Астрономическом институте САН в Братиславе. Суммарные данные приведены в Таб. 1, пока Таб. 2–5 приводят часовые числа метеорных эхо для четырех групп длительностей: $\tau > 0$, $\tau \geq 0.5$ сек., $\tau \geq 1.0$ сек., $\tau > 5.0$ сек. Результаты показывают уменьшение числа наблюдаемых эхо с длительностями через 0.5 и 1.0 сек. во время кульминации радианта потока. (Движение в азимуте и высоте радианта потока приведено на рис. 2.) Возможность обяснения этого эффекта находится в зависимости длительности эха от угла падения метеорного тела в атмосферу Земли (Хайдук 1968а). Зависимость характеристик метеорных эхо от высоты радианта выражена даже в таб. 6 и 7, приводящих изменения средних величин длительности и амплитуды эха в течение наблюдений. Высшие значения приведеных характеристик эха в 1961 г. не обозначают необходимости изменеиня функции светимости метеоров. Они обясняются изменением свойств аппаратуры, изменяющих изображение метеорных эхо. В работе сравниваются группы метеорных эхо для избранных интервалов дальностей следов метеоров. Вследствие учета оптимального угла отражения радиосигнала от метеорного следа и учета коэффициента направленного действия антены избранные интервалы дальностей содержат в одном случае преимущественно метеоры потока и в другом случае большинство спорадических метеоров. Из таб. 8–11 возможно этим способом определить отношение числа спорадических метеоров к числу метеоров потока. Это отношение зависит даже от интервала долготы Солнца, дневного периода и методов наблюдений (Хайдук 1968б). Для сравниваемых групп метеоров определены коеффициенты функции светимости $\kappa_{sb} = 2.7$ для метеоров потока и $\kappa_{sp} = 3.6$ для спорадических метеоров. Эти результаты сходятся с результатами оптических наблюдений (Кресакова 1966) и подтверждают относительный недостаток мелких частиц в метеорных потоках. Вариация часового числа метеоров в направлениях орбиты Земли и орбиты роя подтверждает волокнистый характер строения роя Орионид отождествленный с учетом богатых данных наблюдений от начала нашего столетия (Хайдук 1970).