A RADIOLOCATION EXPERIMENT FOR THE DETECTION OF THE VARIATION OF METEOR ECHO CHARACTERISTICS WITH THE DIRECTION OF THE ANTENNA BEAM

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Abstract: Observational data from an experiment of recording radar meteor echoes with the antenna beam alternatively directed to a shower radiant and 90° from the radiant, at the same elevation, are presented. The observations were made at the time of the Orionid meteor showers in 1962 and 1963, and some of the results have been published elsewhere (Hajduk, 1975). Variations of the mean echo duration, echo amplitude, amplitude fluctuations and other characteristics are tabulated in this paper.

Observations

In addition to the previous paper (Hajduk, 1975) dealing with the results of an experiment carried out with meteor radar of the Ondřejov Observatory, the relevant observational data are presented here in more detail.

The time intervals, of particular observations are listed in Table 1, where A is the azimuth , ΔA the azimuthal difference between the direction of the antenna beam axis and the shower radiant. As the antenna is fixed at the elevation of 45° and steerable in azimuth, the observations at $\Delta A = 0°$ have been made with antenna beam axis directed into the shower radiant and the observations at $\Delta A = 180°$ at a right angle to the shower radiant. Check observations were made with the antenna orientation to the north (A = 180°).

Echo Durations

As it was shown in the mentioned paper, the differences in hourly rates and in the proportion of long duration echoes can be explained by the presence of shower meteors also in observations with antenna beam axis oriented into the shower radiant (see also McIntosh, 1968). The shower meteors appearing in these observations mostly refer to overdense trains at higher distances. The relative numbers of echoes and the mean values of the echo duration in four duration levels can be found in Tables 2 and 3.

Echo Amplitudes

The mean values of echo amplitudes do not show any significant changes with antenna orientation. If the smallest echo amplitudes are excluded ($y \leq 4$ in relative units, measuring the vertical size of the echo image on the range-time record), a decrease of the mean echo amplitude was observed at $\Delta A = 0°$. The variation of echo amplitude with radiant position relative to the antenna beam axis can be examined in more detail in Tables 4, 5 and 6. The range distribution of echoes of different cathegories of amplitude shows a very broad maximum at ΔA= 0° as compared with the other two cases. This can be explained by the elimination of the main shower maximums in the range distribution of echoes, because the condition of specular reflection is not fulfilled at the distances of about 170 km, contrary to the regular observations at A = 180° (see McKinley and Millman, 1949 and Hajduk, 1968). An other aspect of this problem can by studied using the variation of the fluctuation rate of echo amplitudes with range.

Amplitude Fluctuations

Two categories of echo amplitude fluctuations have been examined: short period fluctuations less than 1 second (category *a)* and long period fluctuations of more than 1 second (category *b)*. The variation of the fluctuation rate with the

Table 1

Year	Month	Day	Int. No.	Obs. time	N_{all}	Int. No	Obs. time	N_{all}
Observations at ΔA = 180° (shower period)								
62	10	19	1	01:30–02:30	156	6	06:10–07:10	130
62	10	21	2	01:30–02:00	37	7	06:10–07:10	119
63	10	22	3	01:30–02:00	93	8	06:10–06:40	105
63	10	23	4	02:00–02:30	86	9	06:40–07:10	73
62	10	24	5	02:00–02:30	89	10	06:40–07:10	77
Observations at ΔA = 0° (shower period)								
62	10	19	11	–	–	16	–	–
62	10	21	12	02:00–02:30	26	17	–	–
63	10	22	13	02:00–02:30	35	18	06:40–07:10	40
63	10	23	14	01:30–02:00[x]	9	19	06:10–06:40	55
62	10	24	15	01:30–02:00	31	20	06:10–06:40	52
Observations at A = 180° (shower period)								
62	10	20	21	01:30–02:30	193	23	06:10–06:10	181
62	10	23	22	01:30–02:30	138	24	06:15–07:15	121
Observations at ΔA = 180° (background)								
62	10	27	25	01:30–02:00	39	26	06:10–06:40	48
Observations at ΔA = 0° (background)								
62	10	27	27	02:00–02:30	19	28	06:40–07:10[xx]	21

[x]Net time 22 min.
[xx]Net time 20 min.

Table 2

	Shower period	Summary data		Background	
	ΔA = 180° (Int. 1–10)	ΔA = 0° (Int. 11–20)	ΔA = 180° (Int. 21–24)	ΔA = 180° (Int. 25–26)	ΔA = 0° (Int. 27–28)
N_{all}/h	148	74	158	87	48
N_{all}	965	248	633	87	40
$N_{\tau\geq 0.5\ s}$	301	89	220	28	19
$N_{\tau\geq 1\ s}$	94	33	69	8	7
$N_{\tau\geq 5\ s}$	27	11	19	1	0
$\bar{\tau}_{all}$	0.36	0.42	0.39	0.36	0.44
$\bar{\tau}_{\geq 0.5\ s}$	0.99	1.19	0.98	0.90	0.83
$\bar{\tau}_{\geq 1\ s}$	3.01	3.77	2.90	2.05	1.27
$\bar{\tau}_{\geq 5\ s}$	11.84	20.39	9.77	5.50	–
$N_{rel\geq 0.5\ s}$	31.2	35.9	34.8	32.2	47.5
$N_{rel\geq 1\ s}$	9.7	13.3	10.9	9.2	17.5
$N_{rel\geq 5\ s}$	2.8	4.4	3.0	1.1	0.0
$\bar{y}_{all}$	4.93	4.93	5.23	4.94	4.60
$\bar{y}_{y>4}$	5.44	5.35	5.59	5.11	4.78
$N_{y>4}$	767	204	547	80	36
$\bar{R}_{all}$	198.5	220.0	195.4	212.9	201.5
$\bar{R}_{R<300}$	167.1	179.6	172.2	167.0	168.9
$N_{R<300}$	841	209	567	70	35

Table 3

Int. No.	τ_{all}		$\tau > 0.5s$			$\tau > 1s$			$\tau > 5s$	
	N	$\bar{\tau}_{log}$	N	N_{rel}	$\bar{\tau}_{log}$	N	N_{rel}	$\bar{\tau}_{log}$	N	N_{rel}
1	156	0.37	56	35.9	0.97	17	10.9	2.7	6	3.8
2	37	0.33	11	29.7	0.82	4	10.8	1.4	0	0.0
3	93	0.35	25	26.9	1.04	7	7.5	4.8	3	3.2
4	86	0.38	25	29.1	1.19	10	11.6	3.9	5	5.8
5	89	0.38	31	34.8	0.89	10	11.2	2.1	2	2.2
6	130	0.38	45	34.6	0.86	11	8.5	2.4	2	1.5
7	119	0.39	40	33.6	1.16	14	11.8	3.9	5	4.2
8	105	0.37	29	27.6	1.00	8	7.6	3.8	2	1.9
9	73	0.29	14	19.2	0.97	5	6.8	2.3	0	0.0
10	77	0.38	25	32.5	1.02	8	10.4	3.5	2	2.6
11	–	–	–	–	–	–	–	–	–	–
12	26	0.48	10	38.5	1.56	4	15.4	7.0	2	7.7
13	35	0.35	9	25.7	1.62	4	11.4	4.4	2	5.7
14	9	0.38	5	55.6	0.68	1	11.1	1.5	0	0.0
15	31	0.48	10	32.3	1.30	5	16.1	2.8	1	3.2
16	–	–	–	–	–	–	–	–	–	–
17	–	–	–	–	–	–	–	–	–	–
18	40	0.41	19	47.5	0.90	5	12.5	2.8	1	2.5
19	55	0.41	20	36.4	1.09	7	12.7	3.2	2	3.6
20	52	0.41	16	30.8	1.51	7	13.5	4.9	3	5.8
21	193	0.39	76	39.4	0.94	24	12.4	2.4	6	3.1
22	138	0.50	65	47.1	0.99	22	15.9	2,6	5	3.6
23	181	0.36	44	24.3	1.24	14	7.7	5.4	7	3.9
24	121	0.34	35	28.9	0.81	9	7.4	2.4	1	0.8
25	39	0.45	16	41.0	0.95	5	12.8	2.4	1	2.6
26	48	0.31	12	25.0	0.84	3	6.3	1.6	0	0.0
27	19	0.51	10	52.6	0.92	5	26.3	1.2	0	0.0
28	21	0.38	9	42.9	0.75	2	9.3	1.3	0	0.0

range in different observations can be seen in Table 7.

It can be clearly recognized that both the fluctuation rate per second ($N_{min/s}$) and the relative number of fluctuations (N_{min}/N_{all}) in the observations with beam directed into the radiant ($\Delta A = 0°$ e.g. Int. No. 11–20 of Table 1) continuously decreases up to the range 160–185 km, and increases again towards larger distances. The only significant exception is the range interval 190–215 km.

The range interval 160–185 km coincides with the specular reflection in regular observations of the Orionids at $A = 180°$ (see Hajduk, 1968). The absence of shower meteors in the observations at $\Delta A = 0°$, even in this range interval, suggests a dependence of the fluctuation rate on the orientation of a meteor train. The fluctuation rate increases with increasing angular distance between the train and the beam axis.

In the same way we can explain an increase of the fluctuation rate at the range interval 190–215 km at $\Delta A = 0°$, as mentioned above. In the period of the Orionid shower Taurid meteor showers are already active. The difference in *A.R.* between the radiants of the Taurids and the Orionids is about 45°. Hence, at the time when the axis of the antenna beam is oriented to the Orionid shower radiant (at $\Delta A = 0°$), the Taurid radiants are 45° from the beam axis. Due to the higher declination of the radiant, the maximum of recorded Taurid meteors is shifted towards larger distances. This location of the Taurids in the range distribution of echoes has been also shown in the analysis of the Orionid data (Hajduk, 1968).

Head Echoes

The number of meteoric head echoes recorded is small due to the limited observing time. However, in comparison with the usual method of observation at $A = 180°$, when 10 head echoes were recorded in 4 hours, at the observations at $\Delta A = 0°$ only 2 head echoes were recorded in 3.4 hours. The observations at $\Delta A = 180°$

Table 4

$\Delta A = 180°$

R \ y	2	3	4	5	6	7	8	9	10	11	12	13
85					1							
90		2	2		2							
95				2	1	1						
100		1	6	3	1	1						
105	1	2	6	3	3	2	1					
110	1	9	6	5	2	2	4				1	
115	1	4	13	1	2	4	1	1				
120	1	9	8	6	3	1	3		1			
125		3	9	5	2	2	2	3			1	
130		8	13	2	2	4	2	1	1		1	
135	2	12	13	6	5	2	3	3	2	2		
140	1	10	16	10	9	7	1		5	1	1	
145	1	12	15	3	6	1	6		2	2		
150	1	1	9	9	3	3	1	3	2	2	1	
155		7	14	8	4	3	3	1	2			
160	1	11	11	5	5	3	1		1	1	1	
165		4	8	6	5	4	2					
170		8	10	6	4	1					1	
175		1	5	1	2	1			1	1		
180	1	7	18	2	3	1	1	1				
185	1	5	5	6	3					1	2	
190		4	6	1	3	1	1					
195		5	7	4	1		1					
200			8	4	3		1					
205		2	6	3			1		1			
210			5	3	1				1			
215		4	5	1	4		2					
220		3	5	1	4	2			2			
225		2	4	3	5	1	2					
230		7	5	2	3		1		1			
235		2	3	2	3	1						
240		2	6	4	4	1						
245		2	6	1	3							1
250			2	2	1	1			1			
255		3	6	1	1		1				1	
260		1	7	4	1			1	1			
265		1	5	2								
270		1	6	6	2	1						

Table 5

$\Delta A = 0°$

R \ y	2	3	4	5	6	7	8	9	10	11	12	13
85			1									
90			1									
95		1										
100			2	1	1							
105				1								
110		1	2		1							
115		3	1		1							
120		1	4	1	1			1	2			
125		2	2			1						
130			3	1								
135			3	1	1	1	1	1		1		
140		2	1	3	1							
145		2		2	1	1		1				
150			3			1					1	
155			2		3		2	1				
160		2	7	2	2		1	1				
165			3	1	1							
170		3	1	1	2		1		2			
175			3	1								

Table 5 continued

R \ y	2	3	4	5	6	7	8	9	10	11	12	13
180		1	3				1	1	1			
185			3	2	2		1					
190			2	2	1							
195		1	4	1			1					
200			2		1		2					
205			6	1								
210		2	1	2	1			1				
215		1	3	2		1						1
220		1	1		1							
225		1		1	2	1						1
230			3	2		1						
235			2		1							
240		3	3	1		1						
245		1	1	3		1						
250			1	2	1							
255			1									
260		1	3	2	1							
265						1						
270			3	1								

Table 6

$A = 180°$

R \ y	2	3	4	5	6	7	8	9	10	11	12	13
85		1										
90		2			1							
95		2	2	2					1			
100		1	5	4		1						
105			2	2	4		1	1				
110		5	11	2			1	1				
115		4	7	3	3	1			1			
120	1	6	12	3	3	1	0	2	0	1		
125		4	3	3	1			2				
130		2	11	2	2	1	3		1			
135	1	8	7	3	4	2	1		1	1		
140		5	10	5	3	1			1	1		
145		4	9	2	5	1	2	1		1		
150			10	4	7	1		2	3			
155		1	4	5	2	1						
160		1	7	4	7		1		2	1	1	
165			6	6	3	1	1			1		
170		2	5	4	1	2		1	1	1	1	
175		3	3	3	1	1	1		1			
180			1	1	4				1			
185		1	5	3	2		4			4		
190		1	5	4	2	4	1		1	2	1	
195			9	2	2	2	1		2	1	1	
200			7	3	1	2	2	3			1	
205		1	4	3	1	1	1					
210			1	5	1		1	1	3			
215			4	2	1		1					
220		2	8	4	1			1				
225		2		2	1		3	1	1			
230		1	3	4	4	2	2	1				
235		1	1	1	2	1						
240		2	7		1		1	1	1			
245		2	8		1	1		1	1			
250		1	3	1		1						
255		3	3	2	2			1	1			
260		2	6	3	1		1					
265		1	3		1							
270		2	4	2		1	2					

Table 7

ΔR	Int. No.	$N_{\Delta R}$	$N_{min(a)}$	$N_{min(b)}$	$N_{min(a)}/s$	$N_{min(b)}/s$	$N_{min(a)}/N_{\Delta R}$	$N_{min(b)}/N_{\Delta R}$
70	1–10	11	20	11	1.44	0.44	1.82	1.00
	11–20	3	6	5	1.11	0.33	2.00	1.67
125	21–24	8	16	5	1.50	0.25	2.00	0.63
130	1–10	13	36	23	1.63	0.35	2.77	1.77
	11–20	5	10	4	1.20	0.18	2.00	0.80
155	21–24	13	24	12	1.32	0.35	1.85	0.92
160	1–10	21	46	39	1.53	0.28	2.19	1.86
	11–20	8	12	7	1.24	0.09	1.50	0.88
185	21–24	17	39	14	1.52	0.31	2.29	0.82
190	1–10	9	19	7	1.56	0.26	2.11	0.78
	11–20	5	6	9	0.75	0.50	1.20	1.80
215	21–24	10	23	16	1.52	0.34	2.30	1.60
220	1–10	28	55	41	1.53	0.29	1.96	1.46
	11–20	9	15	14	1.27	0.18	1.67	1.56
275	21–24	15	40	29	1.76	0.29	2.67	1.93
300	1–10	34	80	32	1.67	0.17	2.35	0.94
	11–20	8	23	26	1.84	0.26	2.88	3.25
600	21–24	10	31	15	1.97	0.24	3.10	1.50
	1–10	116	256	153	1.58	0.26	2.21	1.32
R_{all}	11–20	38	72	65	1.29	0.21	1.89	1.71
	21–24	73	173	91	1.60	0.29	2.37	1.25

give 17 head echoes in 6.5 hours. As the head echoes appear within the most sensitive region of the radar we can conclude that the proportion of head echoes belonging to the shower meteors in regular observations may be even higher than 2:1 as it was estimated previously (Hajduk, 1972). The lack of head echoes at $\Delta A = 0°$ may be due to geometrical effects of the head echo formation.

Most of the head echoes observed were immediately followed by long duration echoes.

Conclusions

The present data in connection the results derived previously from the same experiment (Hajduk, 1975), support a fairly large variation of the echo parameters in dependence of the angle between the antenna beam axis and the position of the meteor radiant.

The geometry of the reflection modifies the range distribution of echoes at different amplitude levels. The amplitude fluctuation rate increasis with increasing angular distance to the position of radar. The ratio of head echoes shows a strong dependence on the trail orientation, preferring meteors passing at high angular distance from that of parallel with the beam axis.

Due to the radiant distribution of sporadic meteors, with concentrations in particular directions (Hawkins, 1956; Davies, 1957) and with seasonal changes (Štohl, 1968), the hourly rates and other parameters of sporadic meteor echoes should also depend on the direction of the antenna beam.

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EXPERIMENT NA URČENIE VARIÁCIE CHARAKTERISTÍK RADAROVÝCH OZVIEN METEOROV ZMENOU SMERU LOKÁCIE METEORICKÝCH STÔP

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Súhrn

Práca obsahuje ďalšie výsledky experimentu uskutočneného v období činnosti meteorického roja Orioníd v r. 1962 a 1963 metódou striedavých zmien smeru osi anténnej sústavy. Doplňa predchádzajúcu prácu (Hajduk,1975) ďalšími analýzami. Pre tri zvolené smery anténneho zväzku voči radiantu roja sú určené frekvencie ozvien jednotlivých kategórií trvaní, priebeh stredných hodnôt trvaní a amplitúd pozdĺž osi vzdialeností a ďalšie charakteristiky radarových ozvien meteorov. Výsledky ukazujú závislosť fluktuácie amplitúd ozvien a výskytu čelných ozvien meteorov od geometrických faktorov.

РАДИОЛОКАЦИОННЫЙ ЭКСПЕРИМЕНТ ДЛЯ ДЕТЕКЦИИ ИЗМЕНЕНИЯ ХАРАКТЕРИСТИК МЕТЕОРНЫХ ЭХО С НАПРАВЛЕНИЕМ ДО СЛЕДА МЕТЕОРА

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Резюме

Предлагаются результаты экспериметра с 1962 (19–24 окт.) и 1963 (22–23 окт.) гг. по наблюдениям радиоэхо метеоров с изменением направления антенны в сотвeтствии с радиантом потока. Дополняются данные предшествующего анализа (Хайдук, 1975). Приводятся часовые числа эхо по категориям длительностей, средние значения длительностей и амплитуд эхо в распределении их дальностей и другие характеристики метеорных эхо. Результаты наблюдений показывают зависимость флуктуаций амплит уд эхо и часоты появления головных эхо от геометрических эффектов.