SIMULTANEOUS OBSERVATIONS OF METEORS WITH THE RADAR AND TV SYSTEMS

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Abstract. We have carried out a simultaneous observation of radar and optical meteors with the MU radar (Middle and Upper Atmosphere Radar), Shigaraki and TV camera systems. We usually obtained about 20 meteors per an hour with 85 mm lens, but very small part of them are simultaneously observed by the MU radar ($< 5\%$), suggesting the significance of rectangular scatterring. We have analyzed about 20 simultaneous meteors with magnitudes from 0 to +5.5, most of which are overdense meteors. For Geminid meteors, a linear relation between the logarithm of the echo duration and the absolute magnitude of the TV meteor, was deduced.

Key words: TV and radar meteor observation; Geminids

1. Introduction

The observation of meteors has been carried out by optical methods and the radar. In optical methods, the visual and photographic observation has been performed over 50 years. Recently, the TV observation using an image intensifier was put to practical use, and many amateur observers have began to carry out the TV observation. In the TV observation, there is the large merit that the faint meteors which cannot be observed by the visual and photographic methods can be observed (Hawkes and Jones, 1986; Hawkes, 1993). On the other hand, it has been said that in the radar observation, generally fainter, namely smaller meteoroids can be observed than at the visual and photographic observations, but it undergoes a number of limitations due to the scattering condition of the radio wave (McKinley, 1961). Therefore, in order to determine the relation between the optical and radar meteor, we carried out simultaneous observation using the radar and TV cameras. From the simultaneous observation by the radar and TV cameras, it is expected to get information about

- the accuracy of determination of the direction, from which meteor echoes arrive
- the derivation of the relation between the luminosity of faint optical meteors and intensity of the radio wave reflection and the duration of echoes (ionization),
- the scattering mechanism of meteor trails
- the reexamination of meteor flux density into the earth atmosphere.

(Babadzhanov and Malyshev, 1987; Cook et al, 1972)

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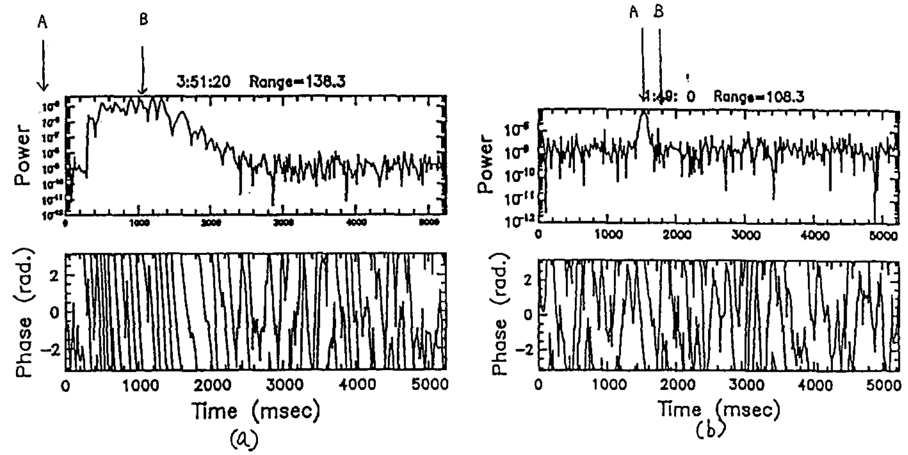
2. Equipment and observations

The radar observations were carried out by the MU radar (Middle and Upper Atmosphere Radar) of the Radio Atmospheric Science Center, Kyoto University, and the TV observations were carried out at three sites: Shigaraki MU Observatory, Shiga; Muro, Nara and Kashiwara, Nara. The MU radar is operated at the frequency of 46.5 MHz, and the peak power of 1 MW (Nakamura et al, 1991). By using an interferometer with four receiver channels, the arrival direction of a meteor echo can be determined. The beam pattern of the MU radar has been measured. This provides useful information for the identification and analyses of simultaneous meteors. The TV systems consist of bright object lenses (f = 24-200 mm, F = 1.2-2.0), image intensifiers (Hamamatsu V3287P) and 8 mm video-recorders. A personal computer with an image processing board employed in the positional and photometric measurement of TV meteors (Fujiwara, 1993). The judgement of the simultaneity of meteors was performed by using the time of appearance and the positions of the TV and radio meteors. Multi-station observations were carried out in order to determine the atmospheric trajectory (and orbit). Preliminary simultaneous observations were carried out in December 12-15, 1991 and December 25, 1993. Fig.1 shows examples of underdense and overdense echoes of meteors observed simultaneously by the TV camera.



A: TV meteor appearance

B: TV meteor disappearence

Fig.1: Examples of overdense (a) and underdense (b) echoes of meteors.

3. Preliminary results

The observational data are summarized in Table 1. We usually obtained about 20 TV meteors per an hour by 85mm lenses (about 70 percent of them were fainter than +4 mag.), but only very small part of them was simultaneously

Table 1: Summary of the observational data

Result of the simultaneous observation in Dec. 1991

Date	Time(UT)	lens	F.V.	TV1	TV2	MU1	MU2	MU3	S.M.	A	B
(1) 12	13:03-15:56	24mm	50	37	25	1314	835	100	1	4.0	1.0
(2) 12	15:57-20:46	85mm	16.9	172	106	3002	1962	13	1	0.9	7.7
(3) 13	12:52-20:37	85mm	16.9	256	141	4834	3152	141	1	0.7	0.7
(4) 14	12:31-14:47	58mm	25	31	17	1257	751	87	11	64.5	12.6
(5) 14	14:50-19:55	85mm	16.9	155	93	2970	1705	21	1	1.1	4.8
(total) 3	1368min			651	382	13377	8405	244	15	3.9	6.1
							except of (4).			1.1	2.5

Obs.No.(4):TV camera was directed toward the theoretical reflecting area of Geminids.

Result of the simultaneous observation in 25 Dec.1993

Date	Time(UT)	lens	F.V.	TV1	TV2	MU1	MU2	MU3	S.M.	A	B
(1) 25	15:45-17:04	85mm	17	19	13	334	266	6	0		
(2) 25	15:10-19:03	85mm	17	35	27	663	583	17	1		
(3) 25	15:46-17:10	135mm	10	13	10	358	283	4	1		
(4) 25	16:00-16:58	85mm	17	17		257	196	4	0		
(5) 25	15:46-17:01	85mm	17	17	9	321	261	6	0		
(6) 25	17:05-19:04	85mm	17	72	49	694	613	11	1		
(7) 25	16:16-18:20	200mm	7	20	12	677	496	4	1		
(8) 25	15:46-17:03	50mm	27	14	9	332	268	12	0		
(total)	709min			207	(129)	3636	2966	64	4	3.9	6.2

TV1:Total number of TV-meteors TV2:Number of TV-meteors during the transmission of the MU Radar.
MU1:Total number of the echoes MU2:Number of the echoes determined the reflecting point.
MU3:Number of the echoes reflecting from the field of view of TV.
Lens:the focal length of the object lens(mm) F.V.:field of view of TV (degree)
S.M.:Number of the simultaneous meteors
A : (S.M./TV2) %
B : (S.M./MU3) %

observed by the MU radar (< 5%). The result stresses the significance of rectangular scattering from meteor trails, particularly for the faint meteors. This is supported by the result that the rate of simultaneity was conspicuously high in the case of carrying out the TV observation taking the theoretical reflection region of the Geminids as the central field of view. This region was derived using a simple geometric procedure based on the property of specular reflection from meteor trains (Poole and Roux, 1989). As Lindblad (1963) already pointed out, a linear relation is deduced between the logarithm of duration of the echo and the absolute magnitude of the TV meteor (Figure 2). For the Geminid meteors, the adopted linear relation between the logarithm of duration of the echo and the absolute magnitude of the TV meteor is thus

$$\log \tau = -0.24 MA + 1.20 \tag{1}$$

τ: echo duration in sec.
MA: absolute magnitude of the TV meteor

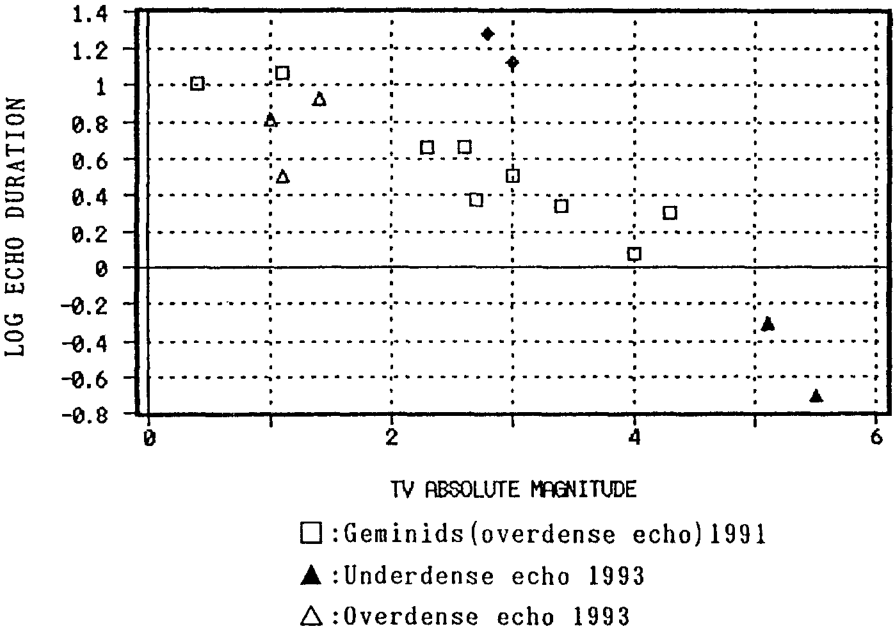


Fig.2: Scatter diagram of the echo duration in seconds versus the absolute magnitude of TV meteors.

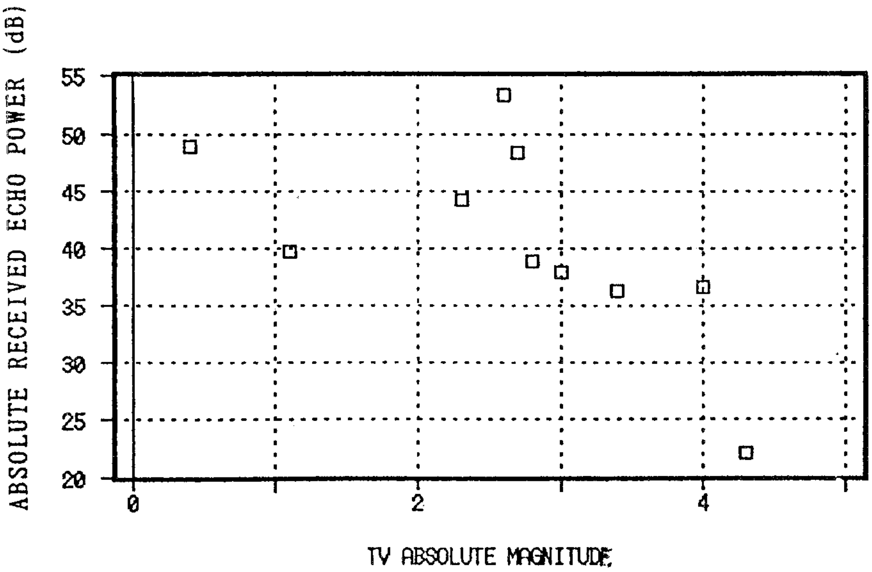


Fig.3: Scatter diagram of the absolute received echo power (dB) versus the absolute magnitude of TV meteors.

The adopted linear relation between the absolute received signal power of the echo and the absolute magnitude of the TV meteor is thus

$$Pa(dB) = -4.6MA + 52.9 \tag{2}$$

Pa: absolute received signal power of echo (dB)

Pa is given by the following equation

$$Pa(dB) = Pr(dB) + 30\log(Range/100) - Gt(dB) - Gr(dB) + N(dB) \tag{3}$$

Pr: observed received signal power of echo (dB); Range: km; Gt: gain of transmitting antenna; Gr: gain of receiving antenna; N: noise level (dB)

In our observation, about 20 simultaneous meteors have been analysed so far, but almost all of them were the overdense echoes. By further observations we hope to collect fainter meteors with a large lens (200 mm), so the underdense echoes will be observed. Then, these simultaneous meteors could provide us important information on the radar meteor scattering and meteor fluxes of the faint meteors.

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