RADIO ECHO OBSERVATIONS OF THE GEMINID METEOR STREAM

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Summary

Measurements of radiant coordinates and echo rates from 1952 to 1957 are summarized. A mean radiant of $\alpha=113\cdot4°$, $\delta=31\cdot4°$ at solar longitude $\odot=260\cdot2°$, a small radiant area, and a markedly asymmetrical distribution of meteors across the stream, with a maximum echo rate at $\odot=260\cdot8°$, all agree with northern hemisphere radio echo observations made between 1949 and 1954.

I. Introduction

With the exception of 1954, observations of the Geminid meteor stream have been made each year from 1952 to 1957. The observations prior to 1956 have already been published (Weiss 1955, 1957). This paper describes the 1956 and 1957 observations and summarizes the measurements of radiant coordinates and echo rates so far obtained.

The observations have been made with two equipments, the 27 Mc/s " wind " equipment and the 67 Mc/s radiant survey equipment. The wind equipment is essentially a C.W. system with a wide-beam aerial directed to the zenith (Robertson, Liddy, and Elford 1953). The radiant equipment (Weiss 1955) is a radar system with two narrow-beam aerials directed at low elevation along azimuths 35·5° S. of E. (termed the N aerial) and 14° N. of E. (S aerial); for the observations in 1956 and 1957 the transmitter peak pulse power was increased to 50 kW. The methods of measuring radiant coordinates, and the accuracy obtained, have been described adequately in the papers cited.

The line densities of electrons in the faintest trails detected by either equipment are close to 10^{11} electrons/cm, corresponding roughly to visual magnitude +7.

II. The Observations for 1956 and 1957

Radiant positions and echo rates are listed in Table 1. The daily shower echo rate is the echo rate remaining after subtraction of the estimated number of sporadic echoes for the periods 23–00½ hr (N aerial) and 03–04 hr (S aerial) from the total numbers of echoes detected during the corresponding periods each day.

III. Radiant Position and Diameter

Radiant positions on individual days are plotted in Figure 1. The radiant ephemeris, estimated by the method of least squares, is:

$$\alpha=113\cdot4°+0\cdot90\ (\odot-260\cdot2)°,$$
$$\delta=\ 31\cdot4°+0\cdot10\ (\odot-260\cdot2)°.$$

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TABLE 1

RADIANTS AND TOTAL ECHO RATES FOR THE GEMINID SHOWER, 1956–1957

Date	Radiant Coordinates				Total Echo Rate			
	1956		1957		1956		1957	
	α	δ	α	δ	N	S	N	S
Dec. 8						4	14	
9					0		0	
10	109	+31				14	17	
11	112	+33			8		24	
12	114	+34	114	+35		34	44	22
13	114	+34			60		58	
14	115	+33	114	+34			64	38
15	116	+33			20		5	
Sporadic echo rate/hr	..	..	..	..	18	22	26	54

The mean radiants for the wind equipment, which are averages over several days, have been excluded. The daily motion in Right Ascension, $0\cdot90\pm0\cdot24°$, is slightly smaller than those given by Lovell (1954) for radio, photographic, and visual measurements. The small daily motion in declination, $0\cdot10\pm0\cdot50°$, is in the opposite sense to the small negative value given by Lovell, but because

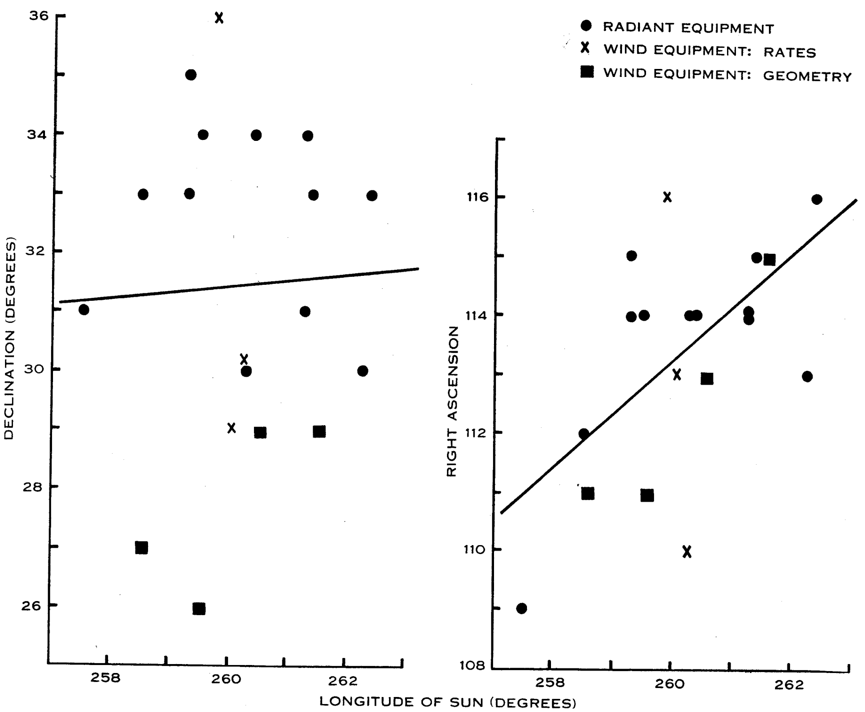

Fig. 1.—Coordinates of the Geminid radiant. The full lines are the least square fits for the daily motions.

of the large standard deviation no significance can be attached to the reversal of direction. In fact, the daily motions found here must be accorded considerably less weight than the northern hemisphere determinations, since at Adelaide the Geminid radiant is unfavourably situated (maximum elevation $<25°$) and the shower echo rate exceeds the sporadic rate for only a few days near the time of maximum activity. The mean radiant of $113 \cdot 4°$, $+31 \cdot 4°$ at $\odot = 260 \cdot 2°$, however, agrees well with the radio radiant of $112 \cdot 9°$, $+31 \cdot 9°$ given by Davidson (1956) for the same epoch.

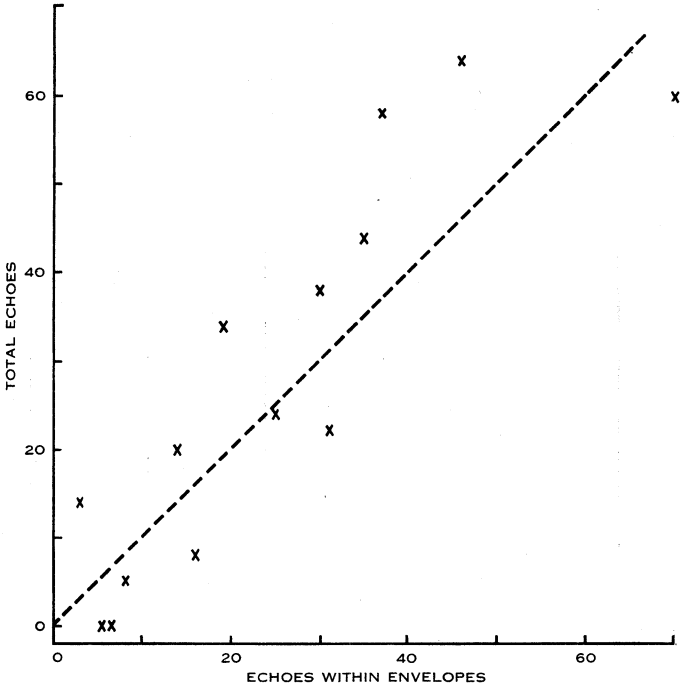

Fig. 2.—Comparison between total numbers of shower echoes each day, and the numbers of echoes falling inside the range-time envelopes corresponding to a point radiant.

Direct measurement of the radiant diameter is precluded by the low echo rate, which even at maximum activity is barely double the sporadic rate (see Table 1). It is, however, possible to compare the total shower echo rate, as listed in Table 1, with the number of shower echoes detected inside range-time envelopes on the corresponding days. This comparison is made in Figure 2, using range-time envelopes which exclude only a small proportion of meteors whose line densities exceed $\alpha = 10^{14}$ electrons/cm at the reflection points. Since an analysis of echo durations indicates that $\alpha \sim 8 \times 10^{13}$ electrons/cm for the largest Geminid meteors detected, Figure 2 suggests that almost all the Geminid echoes are contained within the range-time envelopes corresponding to a point radiant. The scatter in this diagram is attributed to random fluctuations in the sporadic echo rate. The actual diameter of the radiant must then be very small. This confirms the small radiant area found by Bullough (1954) for somewhat brighter meteors, and lends support to his supposition that the large visual radiant area is due to subsidiary radiants whose activity proceeds almost wholly from bright meteors.

IV. Shower Activity

The dependence of shower activity on solar longitude has been determined from the total number of shower echoes detected each day whilst the radiant lies within the collecting areas of the aerials. For the wind equipment this is the total time, 9 hr, for which the radiant is above the local horizon. The narrow collecting sectors of the radiant equipment lead to much shorter collection times, the times of passage of the radiant being $1 \cdot 3$ and $1 \cdot 0$ hr for the N and S aerials respectively. Corrections have been applied to allow for the slight variations in equipment sensitivity which have occurred from year to year, assuming a

Table 2

REDUCED TOTAL ECHO RATES

Date	Wind Equipment reduced to 1952			Radiant Equipment reduced to 1957 N Aerial		
	1952	1953	1955	1953	1956	1957
Dec. 8	0	28	—	20	8	14
9	27	18	—	11	0	0
10	14	62	0	17	28	17
11	87	46	94	—	10	24
12	92	96	66	13*	68	36*
13	154	156	121	87	72	58
14	93	180	128	69*	—	57*
15	15	46	135	40	24	5

* Average for N and S aerials.

constant sporadic meteor flux and with mass distribution parameters $s=1 \cdot 5$ for the Geminids and $s=2 \cdot 0$ for sporadics. The value of $s=1 \cdot 5$, given by Browne *et al.* (1956), has been confirmed locally by an analysis of echo rates at different equipment sensitivities. Radiant equipment echo rates reduced to the 1957 N aerial rate as standard, and wind equipment rates reduced to 1952, are listed in Table 2. Echo rates measured simultaneously in both channels of the radiant equipment have been averaged ; such averages are marked by an asterisk in the table.

The individual measurements and the mean activity curve are plotted in Figure 3, after increasing all radiant echo rates by a factor of $2 \cdot 10$. It is seen that deviations of up to ± 20 per cent. from the mean occur from year to year in the reduced echo rate at maximum. Although this is greater than the ± 7 per cent. deviation found by Davidson (1956) from the northern hemisphere observations, a discrepancy of this magnitude could well be due to the low echo rate, as compared with the sporadic rate, of the stream at Adelaide. Our results, then, confirm the remarkable consistency of the echo rate from year to year. The abnormally high echo rate in 1954 (Davidson 1956) seems to have been an isolated event.

The asymmetrical shape of the activity curve closely resembles that of Bullough (1954). A peak activity at $\odot = 260 \cdot 8°$ over the period 1952–1957 is identical with Bullough's determination for the years 1949–1953. This

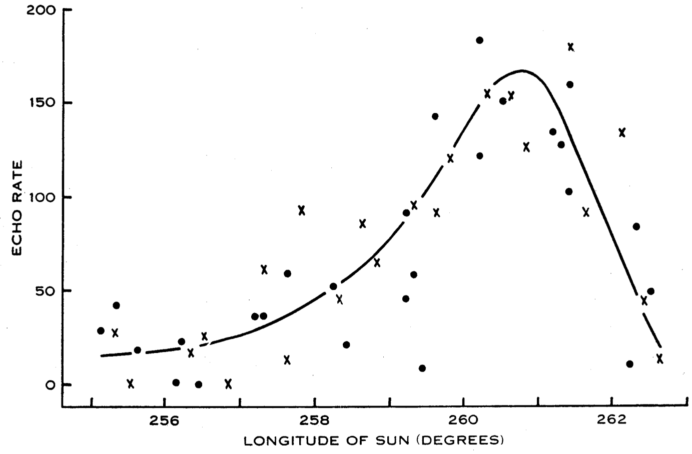

Fig. 3.—Reduced total echo rates for the Geminid radiant. × wind equipment rates ; ● radiant equipment rates multiplied by 2·10.

agreement as to the epoch of maximum activity is important, as it provides a firm initial value for a test of the prediction by Plavec (1950) of a rapid backward shift of the node of this stream, in consequence of which the date of maximum activity moves backwards by one day in 60 years.

V. References

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