THE 1956 PHOENICID METEOR SHOWER

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Summary

From radio observation of this shower at Adelaide the radiant coordinates are estimated to be 15 ± 2, -55 ± 3. The radio record was obtained when the Earth was some 6 hr from the centre of the stream. The radio rate of 30/hr measured on an equipment of high sensitivity is much lower than expected from the visual rates of from 20 to 100/hr reported from 1 to 9 hr later. Echo duration and amplitude are smaller than would be expected from the visual brightness of these meteors. The low radio rate and lack of bright radio meteors could be due to observation on the fringe of the stream or to low ionizing efficiency of slow meteors.

I. Introduction

Visual observations of a new meteor shower, active on the night of December 5, 1956, have been reported by Ridley (1957) and by Shain (1957), who determined radiants in the constellation Phoenix, at 15, −45 and 15, −58 respectively. Orbital elements, computed by Ridley, are similar to the elements of Comet 1819 IV Blanpain as calculated from one apparition only.

This shower was recorded on the 67 Mc/s narrow-beam radar equipment at Adelaide during a routine survey of meteor activity in the southern hemisphere. Since the equipment was described by Weiss (1955*a*) the transmitter power has been increased considerably. At the time of the shower only one recording channel was in operation, and echoes were received only from the S. aerial, whose beam axis is directed at azimuth 14° N. of E., elevation 9°.

II. Radiant and Orbit

A conventional range-time plot of all echoes received from 19.40 to 22.20 hr L.T. is given in Figure 1. As only one aerial was in use, the full potentiality of the equipment for accurate determination of shower radiants could not be realized and recourse to the envelope-fitting method was necessary. Fortunately, for a radiant located so close to the south celestial pole the shape of the range-time envelope is quite sensitive to the declination of the radiant, and the declination can be measured accurately. The error in Right Ascension inherent in the process of fitting a range-time envelope to the observed echoes is small. Range-time envelopes have been calculated assuming a mean meteor height of 90 km. As Phoenicid meteors overtake the Earth from behind, the velocity of entry into the Earth's atmosphere (geocentric velocity) must be low and the mean height should accordingly be somewhat lower than 90 km. However, the error in radiant coordinates introduced by uncertainty in the height is small.

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The radiant coordinates are estimated to be 15 ± 2, -55 ± 3, near the star ξ Phoenix. The fitted range-time envelope in Figure 1 indicates that the radiant area is small.

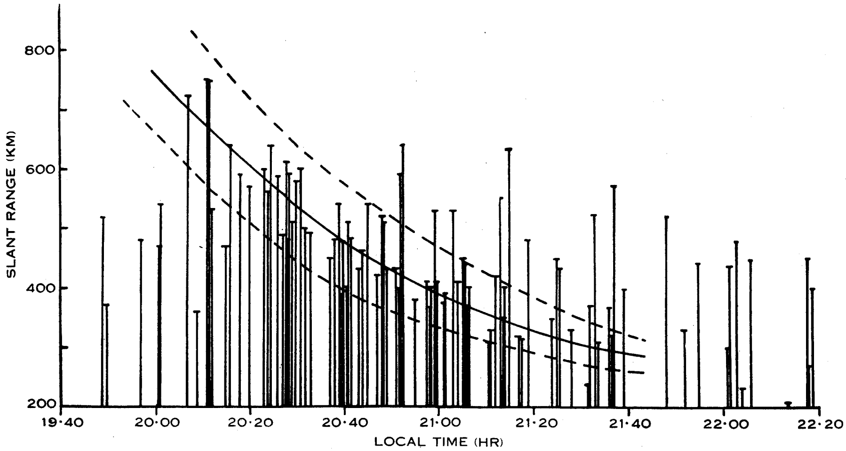

Fig. 1.—Range-time plot of Phoenicid echoes. The fitted envelope is for radiant coordinates 15, —55.

Orbital elements have been computed for this radiant, assuming (*a*) parabolic velocity and (*b*) a period of 5·1 years as suggested by the general similarity

TABLE I

ORBITAL ELEMENTS OF THE PHOENICIDS

Element	Assumed Period	
	∞	5·1 Years
Apparent radiant ..	15, —55	15, —55
Corrected radiant ..	15, —56	15, —58
Apparent elongation ..	125·1°	123·6°
True elongation	160·7°	164·1°
Ω	73·4°	73·4°
ω	0·1°	0·3°
i	19·3°	15·9°
e	1·0	0·667
q	0·985	0·985
Heliocentric velocity ..	42·5 km/sec	38·8 km/sec
Apparent velocity ..	17·1	12·7
Geocentric velocity ..	20·4	16·9

of the parabolic elements with those of Comet 1819 IV Blanpain. These new elements are given in Table 1, along with some data on velocities. They do not agree with the elements of Comet 1819 IV Blanpain as well as the elements already computed by Ridley (1957) for the more northerly radiant. With the exception of the eccentricity, it is clear that the general description of the meteor orbit is not much affected by our lack of precise knowledge of the radiant and velocity.

III. Radar and Visual Rates

The absolute sensitivity of the radio equipment has not been determined, but early in December 1956 the sporadic echo rate was about 600 per day. This far exceeds the visual rate, but, as the character of the diurnal variation at high radio rates appears to differ from the visual diurnal variation, rate comparisons of this type are not a useful index of equipment sensitivity. A more reliable index is provided by the permanent showers.

Radar rates, measured with the Adelaide equipment at high sensitivity, are compared with corresponding visual rates for three showers in Table 2. Visual rates are corrected to a radiant at the zenith. The δ-Aquarid radiant passes through the aerial collecting zone (inclined at an angle of 14° to the north-south meridian) at roughly the same zenith angle, 20°, as the Phoenicid radiant and the geometry of detection for the two radiants will be similar. This is borne out by comparison of the theoretical range-time envelopes. As the two radiants transit so close to the zenith, echo rates have not been corrected. Consideration of the geometry of detection of the Geminid radiant shows that the zenithal correction factor is approximately $\sec^{s-1}z$, where z is the zenith angle of the radiant at detection (here 76°) and s is the mass-distribution parameter ($s\sim1\cdot5$ for the Geminids).

Table 2

ZENITHAL RATES OF METEOR SHOWERS

Shower	Radio Rate	Visual Rate	Authority for Visual Rate
Phoenicids	30	20—100 >60	Ridley (1957) Shain (1957)
δ–Aquarids	150	20	Lovell (1954)
Geminids	120	20—60	Lovell (1954)

Despite the heterogeneous nature of the rates for the permanent showers, there can be no doubt that the echo rate for the Phoenicids, in relation to the visual rates, is surprisingly low. The significance of this low rate is discussed below.

IV. Echo Duration and Amplitude

Echo duration and amplitude were not measured, but some information on these characteristics may be obtained in the following way. At the slow film speed used (12 cm/hr) spot size and intensity are determined jointly by the echo amplitude, which was not voltage-limited, and the echo duration. As large echo amplitude is usually associated with long echo duration, spot size and intensity furnish a rough guide to the echoing area of the meteor trail. Spot intensities have been divided subjectively into four classes and the number-distribution of 59 echoes falling within the fitted range-time envelope is listed in Table 3. This distribution for Phoenicid meteors does not differ significantly from the distribution for an equal number of sporadic meteors taken on either side of the shower.

The inference is that at the time of the Adelaide observations, which extended from 11 to 12.30 hr U.T., the Phoenicids included very few bright radio meteors. This is remarkable in view of the visual observations made very little later. Thus Shain, observing at Sydney, reports visual apparent magnitudes estimated to be about -2; these observations, made from 13 to 13.30 hr U.T., were limited by cloud. Still later, from 16.40 to about 22 hr U.T., South African visual observers reported many meteors of fireball magnitude, with maximum activity occurring round 19 hr U.T. Unusual activity was also reported from New Zealand about 10 hr before the onset of the shower in South Africa. No unusual visual objects were reported at Adelaide, but the sky was almost completely obscured by cloud.

Table 3

COMPARISON OF PHOENICID AND SPORADIC ECHO INTENSITIES

Echo Classification	Phoenicids	Sporadics
1 Weak	14	16
2	18	13
3	18	21
4 Strong	9	9

It is possible that the low radio rate and the deficiency of bright radio meteors resulted from detection at Adelaide whilst the Earth was still on the fringe of the stream. However, the visual record suggests a marked concentration of massive meteor particles to the centre of the stream, without any corresponding concentration of meteor density; and the radiant passed out of the Adelaide collection zone less than an hour before bright visual meteors were reported from Sydney, some 6 hr before the peak activity. Under these circumstances there is an alternative explanation of the Adelaide observations which merits consideration.

The shortest echo duration which can be resolved is limited by film speed and spot size, and is a little less than 10 sec. None of the Phoenicid echoes had durations exceeding this, and the great majority of echo durations were considerably less.

The relation between visual brightness and line density α of electrons/cm in the meteor trail is usually taken to be

$$\log_{10}\alpha = 14\cdot 0 - 0\cdot 4M_v. \qquad \qquad (1)$$

The constant is determined by the condition that $M_v=5$ corresponds to $\alpha=10^{12}$ (see e.g. Browne *et al.* 1956). Substitution of Shain's estimated visual brightness of $M_v = -2$ in (1) gives $\alpha = 6 \times 10^{14}$. Trails with electron densities as high as this give persistent echoes whose duration (Kaiser 1953) is

$$\tau = 1 \cdot 124 \times 10^{-12} (\lambda^2/16\pi^2 D)\alpha. \quad \ldots\ldots\ldots\ldots\ldots (2)$$

With $\lambda = 448$ cm and $D = 4 \times 10^4$ cm²/sec, corresponding to a mean height of 90 km (Weiss 1955*b*), $\tau = 21$ sec. As the Phoenicid meteor velocity is low, the mean height is probably lower than 90 km, which implies a lower mean value for D and hence longer durations. In any case, the height distribution of the shower meteors would also provide some lower values of D. The absence of echoes with resolvable durations would therefore suggest that the visual brightness of the meteors detected at Adelaide was considerably less than that corresponding to $M_v = -2$.

However, relation (1) takes no account of a possible dependence of ionizing efficiency on velocity. The evidence in favour of a strong increase in ionizing efficiency with increasing velocity has recently been reviewed by Weiss (1957). If the expression given by Hawkins (1956) is adopted, (1) must be replaced by

$$\log_{10}\alpha = 11 \cdot 52 + 1 \cdot 56 \log_{10} v - 0 \cdot 40 M_v. \quad \ldots\ldots\ldots\ldots (3)$$

with v in km/sec. Taking as an upper limit for the geocentric velocity $v = 20$ km/sec corresponding to a parabolic orbit, (2) and (3) set an upper limit of $\tau = 8$ sec for visual brightness $M_v = -2$. Even after allowing for meteors below the mean height of 90 km, the absence of resolvable echo durations is now consistent with the visual observations made at about the same time. Low ionizing efficiency would also depress the radio echo rate relative to the visual rate.

Even if the low velocity of the Phoenicid meteors does not afford a complete explanation of the radio observations, it may well be a contributing factor, whose importance can be assessed by combined radar/visual observations on subsequent returns of this stream.

V. References

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