METEOR ACTIVITY IN THE SOUTHERN HEMISPHERE

By A. A. Weiss*

[*Manuscript received February* 25, 1957]

Summary

Activities and radiants of meteor showers detected by radio equipments at Adelaide from 1952 to 1956 are summarized. A composite picture of shower and sporadic meteor activity is compared with a similar picture compiled from northern hemisphere radio counts. The distribution of the radiants of the more important showers reveals a pronounced concentration to the ecliptic, with a component extending to high latitudes.

I. Introduction

At the time of compilation of the preliminary results of the Adelaide radio survey of meteor activity (Weiss 1955) the survey was incomplete, in that data relating to portions of the first half of the year had not been analysed, nor indeed in some part collected. The survey has been continued on a semi-continuous basis, and this paper deals with meteor counts up to September 1956. The analysis of the sporadic background has already been published separately (Weiss 1957, referred to as paper I).

The 1953 survey of southern hemisphere meteors by Ellyett and Roth (1955) was directed to the delineation of the radiant points of active showers and no data on rates have yet been given. By way of contrast, the emphasis in the Adelaide survey has been on meteor rates, and the information available on radiant points is of low accuracy.

The radio equipments used in the Adelaide survey and the methods of data reduction are described in the earlier paper (Weiss 1955).

II. Shower Activity

The actual operating times for the two equipments are indicated by the heavy lines within the body of Figure 4. Eleven showers, which are enumerated in Table 1, have been resolved and identified. All other meteors, comprising unresolved minor showers and true sporadic meteors, are classed as " sporadic ".

The day-to-day variations in activity of the showers detected by the wind equipment are illustrated in Figure 1. This indicates the hourly echo rates, after correction for equipment sensitivity, averaged over the whole time the shower radiants lie above the horizon each day. As already mentioned in paper I, the sensitivity of the equipment has varied by up to 30 per cent. over the period of the survey. The results of paper I (Fig. 6 (*b*)) have been used to define a standard sporadic rate to which the observed shower rates have been corrected. In thus reducing shower activities to a standard sporadic rate no

* Division of Radiophysics, C.S.I.R.O., at Department of Physics, University of Adelaide.

allowance has been made for the different mass-distributions of shower and sporadic meteors (Bullough 1954), since the mass-distributions of the southern

Table 1

RADIANTS AND ACTIVITIES OF METEOR SHOWERS

Shower \ Year	1952	1953	1954	1955	1956
Corona Australids ..	(*a*)* (*b*) (*c*)	250°, —50° Mar. 16 6		Barely resolved	239°, —45° Mar. 17 4
η-Aquarids			340°, +1° May 5 16	344°, +10° May 10 6	
o-Cetids Day-time Arietids ζ-Perseids	† — June 10 35	— June 9 51	— June 14 40		— June 11 34
β-Taurids	— June 28 9		— June 28 29		— June 26 15
δ-Aquarids		340°, —18°‡ July 27 28	336°, —21° July 29 6		335°, —18° July 25 16
Orionids..	106°, 00° Oct. 20 13	‡ Not detected		102°, +11° Oct. 21 15	
Leonids	Barely resolved			178°, +36° Nov. 14 13	
Puppids	— Dec. 6 7			124°, —36° Dec. 6 7	
Geminids	113°, +29° Dec. 13 26	110°, +30° Dec. 14 24		116°, +36° Dec. 15 23	

* (*a*) Radiant coordinates; (*b*) date of maximum activity; (*c*) activity (hourly rate) at radiant elevation 20° on the date of maximum activity.

† Individual showers not resolved by equipment.

‡ Measured with radiant equipment.

showers are unknown. However, as the sensitivity corrections are not large and the mass-distributions of the major northern hemisphere showers do not differ greatly from that of sporadic meteors (Browne *et al.* 1956) it is to be expected that these corrected activities will not be seriously in error.

Because both the period of time for which a given shower lies above the horizon and the response of the equipment over this interval depend upon the declination of the radiant, the hourly rates of Figure 1 are no index of the absolute rate or meteor flux. In paper I it was shown that comparative shower rating with the wind equipment is only possible by confining attention to the rates when the radiant elevation is 20° or less. The activities corresponding

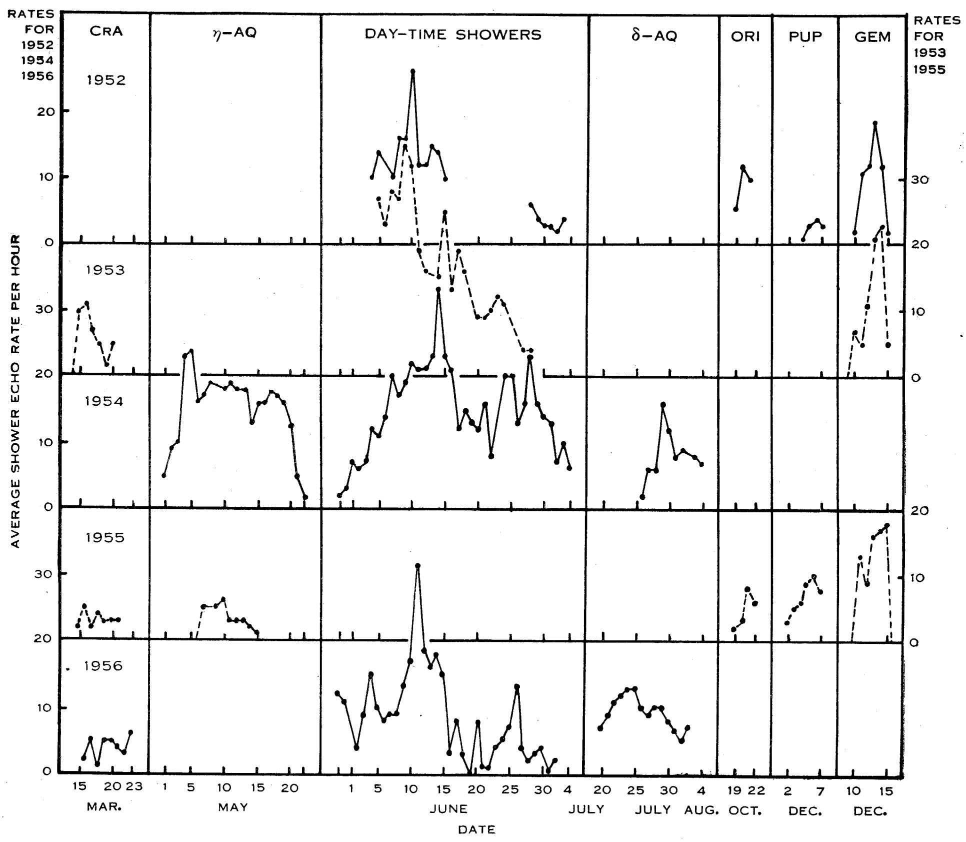

Fig. 1.—Day-to-day shower activities measured with the wind equipment. The activity is an average over the whole time the radiant is above the horizon.

to radiant elevation 20° on the days of maximum activity of the respective showers, and the dates of these maxima, are listed in Table 1. Data for the δ-Aquarids 1953 obtained with the radiant equipment and reduced to the same basis are also included.

Approximate radiants, averaged over the whole periods of activity of the respective showers, are also given in Table 1. The error in Right Ascension may be as large as ±10°. The error in declination depends on the declination of the radiant, being greatest (±10°) for declinations close to 0°, and becoming small for radiants near the celestial poles. The radiants of the June day-time showers, which are above the horizon simultaneously, cannot be resolved by the wind equipment. In view of these errors and the lack of resolving power, the radiants quoted cannot be regarded as accurate fixes of the directions of arrival of shower meteors, but they do serve to locate the centres of activity and hence identify the showers responsible, whose radiants have already been determined with greater precision by other means.

Detailed comments on these showers follow.

(*a*) *Corona Australids*

This is a weak shower of variable activity. It was strong in 1953, but barely detectable in 1955 and 1956.

(*b*) η-*Aquarids*

Information on the activity of this shower has been summarized by Lovell (1954, p. 265), who concluded that there were no marked annual changes in the activity. The sustained high activity in 1954 is therefore noteworthy. On this occasion also meteors were detected for a considerable time before the expected rise time of the radiant, and beyond the expected set time ; this implies either a very diffuse radiant, or a compact radiant accompanied by considerable diffuse activity.

(*c*) δ-*Aquarids*

In 1953, according to the radiant equipment measurements, this shower was accompanied by much diffuse activity and minor showers. In 1954 the shower was of short duration, but again in 1956 diffuse activity was prominent. The maximum activity and the date of its occurrence appear to be variable.

(*d*) *Puppids*

This is a weak night-time southern shower which corresponds with the radiant at 114°, —25° reported by Ellyett and Roth (1955).

(*e*) *Geminids*

The maximum activity of this shower for each year since 1949, as observed at Jodrell Bank (Hawkins and Almond 1952 ; Bullough 1954) and at Adelaide is listed in Table 2. The rates have been reduced to constant sensitivity for the respective equipments. There appears to be a steady decline in the activity of this shower.

This tabulation of 11 certain showers consistently detected at Adelaide over a period of several years is much shorter than the list of Ellyett and Roth (1955), who in a survey extending from February to December 1953 in New Zealand report no less than 40 showers. The radiants of Ellyett and Roth have been allotted an arbitrary probability (grades A to D) and no shower echo rates have been given ; in many cases shower identification has apparently depended on groupings of longer-range echoes alone. Only grade A showers are regarded as certain. Of these seven grade A showers, five are active in the period mid July to mid August. The most active shower of this group is the δ-Aquarids. The Adelaide equipment is incapable of resolving the remaining four (presumably weaker) showers in the presence of the more intense δ-Aquarid activity, although as noted above the Adelaide records reveal that much diffuse activity and some minor showers accompany the principal δ-Aquarid shower. There is no trace in the Adelaide records of strong (or even weak) southern hemisphere night activity in June (two grade A showers), nor of day-time activity near the end of October (grade B and C showers). It is important that the existence of this unexpectedly large number of grade B-D showers, whether permanent or periodic, be confirmed by further surveys in the southern hemisphere with equipment of higher discrimination and resolving power than the Adelaide wide-aperture equipment. Such a survey is now in progress at Adelaide.

TABLE 2

GEMINID SHOWER ACTIVITY

Year	Maximum Activity	
	Jodrell Bank	Adelaide
1949	81	
1950	79	
1951	75	
1952	72	26
1953	71	24
1954		—
1955		23

In a rather different category are the one or more diffuse continuing radiants found by Ellyett and Keay (1956) during high-rate surveys in New Zealand during February-March 1956. This activity they attribute to one or more minor showers of steep mass-distribution (deficient in large meteors) whose radiants are located near the Sun and move with the Sun, and which persist over the whole period of 2 months included in the high-rate survey. Such showers would be far below the limiting sensitivities of the Adelaide equipments whose data form the subject-matter of this paper. In this connexion, however, attention must be drawn to the numerous reports in the literature of concentrations of sporadic meteors, defined as meteors not resolved as shower meteors with the particular detecting technique, in the helion and antihelion positions throughout the whole year (for example, Hawkins (1956*b*) and Weiss (paper I) for radio measurements; Prentice (as reported by Lovell 1954, p. 111) for visual measurements; Krésak (1955) for telescopic measurements; and finally Section II of Ellyett and Keay (1956) for the low-rate New Zealand radar survey). These authors are unanimous in attributing these helion and antihelion concentrations to a group of meteors moving in direct short-period orbits of low inclination, which form a prominent feature of the sporadic background of brighter meteors. If this type of orbit extends to the fainter meteors, and the telescopic survey suggests that it does, this would afford a simple explanation of the high-rate counts of Ellyett and Keay, without appeal to their additional hypothesis of minor streams whose width far exceeds that of any other known meteor stream. This alternative interpretation receives some support from the prominent but less regular peaks also found by Ellyett and Keay between 00 and 04 hr, which may be related to the antihelion concentration.

These considerations underline the very great care which must be exercised in the interpretation of simple meteor counts made with equipments which are specifically designed to detect inhomogeneities in the apparent density of radiants over the celestial sphere, whether the inhomogeneities be caused by shower radiants or by anisotropy in the general background of sporadic radiants.

III. The October Sporadic Activity

Two periods have been recognized in October over which the activity increases markedly above normal. These periods of enhanced activity have recurred each year from 1952 to 1955, and appear to constitute permanent features of the annual march of meteor activity. Figure 2 depicts some of the total daily (24 hr) echo rates at Adelaide (wide-aperture equipment, 27 Mc/s) and at Jodrell Bank (rotating aerial which scans the visible hemisphere, 73 Mc/s).

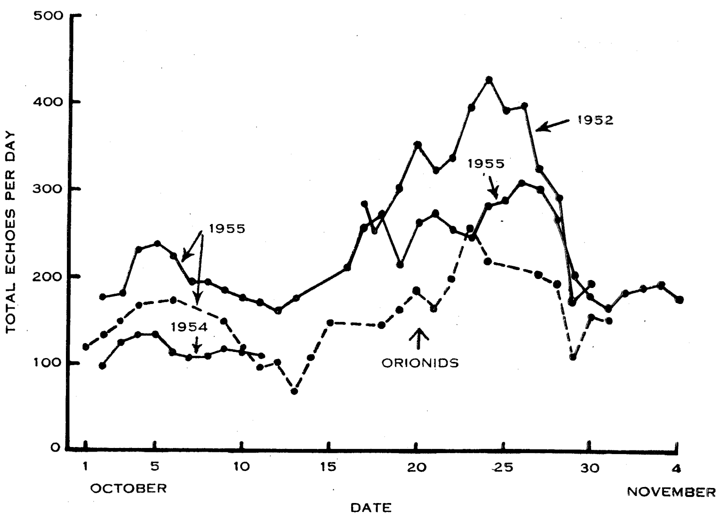

Fig. 2.—Total daily echo rates during the month of October. –●——●– Adelaide ; – ● – – ● – Jodrell Bank.

The peak of activity over October 23–26 is not due to the Orionids, which produce the much smaller peak near October 20. The different responses of these equipments to a shower (Orionids) and to the additional activity, ascribed to sporadic meteors, are illustrated by Figure 3, which shows the excess activity referred to the base days October 1–3 and 7–18 inclusive. The additional activity due to the shower shows an abrupt rise and fall, and symmetry about the time of transit; the earlier onset and later cessation at Jodrell Bank are merely a latitude effect. Shower radiants found from the two sets of data agree remarkably well: they are 102°, +11° (Adelaide), 98°, +11° (Jodrell Bank).

On the other hand, the excess sporadic activity over the period October 23–28 reflects the gradual rise of normal sporadic activity from a minimum at 18 hr to a maximum at 06 hr, which is typical of these wide-aperture equipments (see Figure 5 of paper I). The contrast between the two parts of Figure 3 and the similarity between the curves for the two stations 88° apart in latitude suggest an increase in the incidence of sporadic meteors as the cause of the additional activity.

The small but definite increase in activity over October 3–6 has a similar origin.

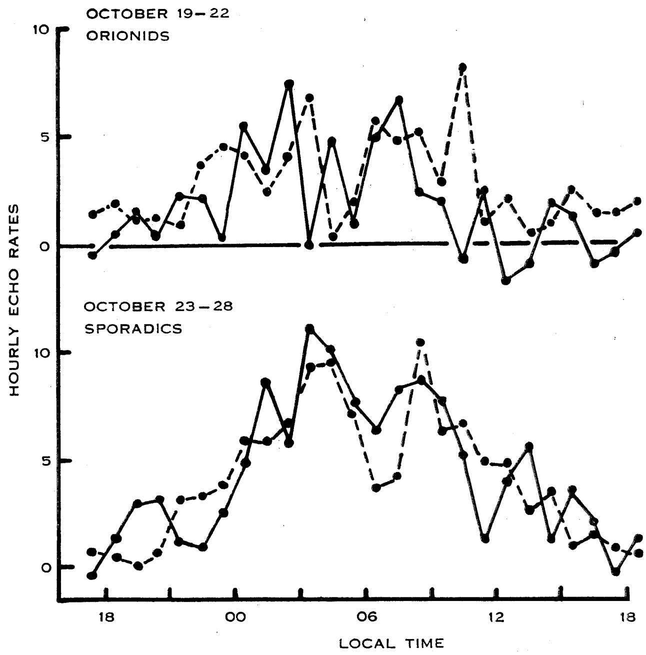

Fig. 3.—Excess hourly echo rates during October. –●——●– Adelaide : – ● – – ● – Jodrell Bank.

IV. The Overall Activity

The shower activity of Figure 1 may be combined with the standard sporadic activity to form a composite picture of the meteor activity over Adelaide for 1952–1956, as measured with the wind equipment. This composite picture is presented in Figure 4 (*a*). The standard sporadic rate (essentially the same as Figure 6 (*b*) of paper I) is shown in histogram form, with the additional contribution from showers superimposed to give the total hourly activity. Meteors whose radiants lie within 40° of the zenith will be undetectable in the major lobe of the wind equipment but may be detected in minor lobes. The factor by which the sporadic rate should be increased to take account of meteors lying outside the limits of the aerial will be less than 2. Figure 4 (*a*) thus represents an approximation to the meteor rates which would be obtained with a radio equipment whose aerial could view the whole of the visible hemisphere.

As already mentioned, the classification of meteors as between showers and sporadics is determined by the resolving power of the equipment. Further, the day-to-day changes in the sporadic rate are not as smooth as the histogram of Figure 4 would suggest. For instance, the uncorrected mean total daily echo rate, and its r.m.s. deviation, for some months considered to be free of showers, are: September 1953 (22 days) 236 ± 32; February 1955 (23 days) 102 ± 22; September 1955 (24 days) 211 ± 22. There are also the two periods of enhanced activity during October (Section III). Six short periods of high activity, distributed throughout the year, have been noted, but, as they have not recurred from year to year and the hourly variation of the excess activity is not suggestive of showers, these periods of high activity are not identified as showers.

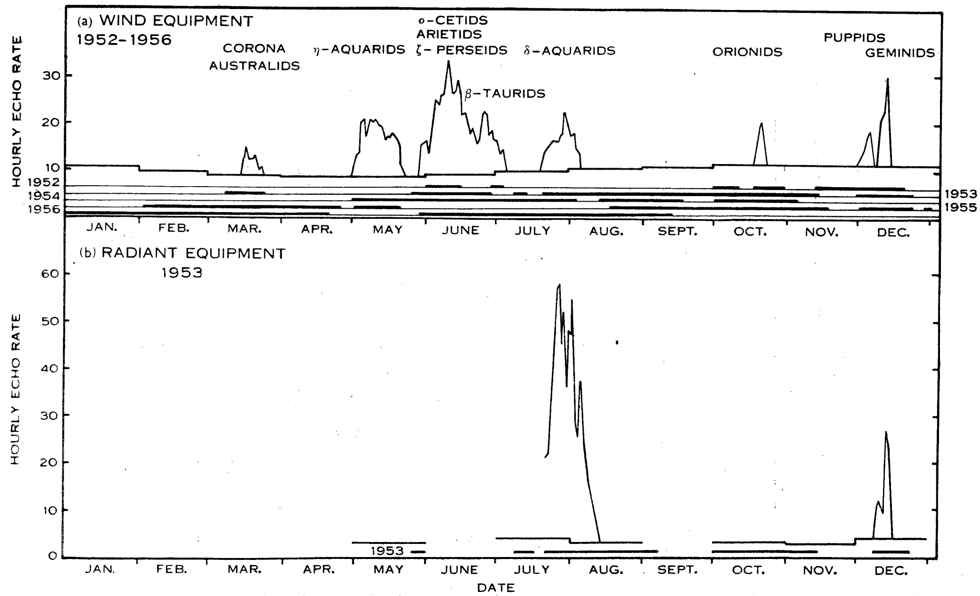

Fig. 4.—Average hourly echo rates, 1952–1956, of sporadic meteors (in histogram form), with shower echo rates superimposed. The heavy lines indicate operating times of the two equipments.

Actual counts with the Adelaide radiant equipment during 1953 are also shown in Figure 4. This equipment has a narrow aerial beam directed at low elevation and detects meteors whose radiants lie in a narrow sector near the north-south meridian. The higher rate of detection of shower meteors by the radiant equipment results from a collecting area larger than that of the wind equipment. Sporadic meteors are collected only from the narrow sector mentioned above, and the correction to the actual sporadic rates of Figure 4 (*b*) to take account of meteors outside this sector is large.

A composite picture of meteor activity measured with this type of equipment, and corrected for aerial aperture, has been given by Whipple and Hawkins (1956). Their Figures 1 (*c*) and 1 (*d*) together form an estimate of northern hemisphere activity detected by a radio equipment whose aerial could view the whole of the visible hemisphere.

Direct correspondence between shower activities measured in the two surveys is not expected, because of the different latitudes of the two stations (53 °N., 35 °S.) and different equipment parameters (aerial polar diagram, collecting area, limiting sensitivity). Rather, Figure 4 (*a*) of the present paper and Figures 1 (*c*) and 1 (*d*) of Whipple and Hawkins should be regarded as complementary so far as the data relating to showers are concerned. The Quadrantids, Perseids, and Ursids lie too far to the north for detection at Adelaide ; the night-time Taurids have not been detected at Adelaide, although weak activity would be expected. The Corona Australids and Puppids are inaccessible to the northern hemisphere equipment ; detection of the η-Aquarids at Jodrell Bank has been reported in the literature (Lovell 1954, p. 265).

Contrary to expectation, the annual variations in the hourly rate of sporadic meteors are not identical for the two surveys. Attention has already been drawn to this discrepancy in paper I. Both surveys agree in finding higher activity in the latter half of the year, but the high sporadic activity found in the northern hemisphere survey over May, June, July, and August does not appear in the southern hemisphere survey. A separation of the Adelaide sporadic counts into day-time and night-time rates (integration limits set at 0600 hr and 1800 hr L.T.) shows that these counts also divide equally between day and night. The criticism might be made that the diagrams under comparison refer to actual counts, and that the disagreement might be reduced or eliminated if corrections for the annual motion of the ecliptic were applied to the data. However, these corrections, which are not large, have been applied to both sets of data in the simple case of a source of sporadic meteors anisotropically distributed round the ecliptic (Figure 13 of paper I for the Adelaide data ; Figure 10 of Hawkins (1956*b*) for the Jodrell Bank data), but the discrepancy remains.

Shower echoes have not been excluded from the total echo counts of Ellyett and Keay (1956) and the data are incomplete in that no records are available for the interesting 8 hr about the time of passage of the antapex through the collecting sector. Despite these limitations there can be no doubt that the New Zealand survey implies a distribution of the average hourly rate of sporadic meteors throughout the year which is similar to that found by Whipple and Hawkins (1956) from the more comprehensive analysis of the Jodrell Bank data. The New Zealand survey was made with the same type of equipment, held at roughly the same sensitivity, as the Jodrell Bank surveys. Other than discounting the highly improbable hypothesis of a latitude effect, the New Zealand data throw no light on the discrepancy in the annual variation disclosed by the other two surveys.

Ignoring this discrepancy for the moment, and allowing for a small increase in the Adelaide sporadic rates to take account of the undetected meteors which fall outside the aerial collecting zone, it is seen that during periods of shower activity the rate of detection of shower meteors is approximately equal to the rate of detection of sporadic meteors over the whole of the visible hemisphere. It must be stressed that this equality refers to the rates of detection of shower and sporadic meteors, and does not necessarily extend to meteor *fluxes*. If, as Hawkins (1956*a*) suggests, the probability of ionization β of an evaporated meteor atom depends strongly on the geocentric velocity v, $\beta \sim v^{5\cdot 6}$, then the relative fluxes of shower and sporadic meteors may differ considerably from their rates of radio detection. Kaiser (1955) concluded from radio-echo rates that the incidence on the Earth of meteors brighter than radio magnitude $m=5$ is approximately the same for various major showers and for sporadic meteors, but this comparison was made on the untenable hypothesis of a uniform geocentric radiant distribution for sporadics. The analogous problem, that of the determination of the space density of visual meteors for which the light intensity is proportional to v^3, has been examined by Levin (1955). He finds, for meteors brighter than $m=4\cdot 3$, a picture of stream densities which differs sharply from the observed visual counts, and a density of sporadic meteors some ten times greater than the central parts of the major streams. Accordingly, whilst the conclusion of Whipple and Hawkins (1956) that certain meteor streams represent insignificant changes in the southern hemisphere meteor flux is almost certainly correct, this is not a conclusion which follows directly from the radio counts.

V. The Distribution of the Radiants of Major Showers

Meteor activity in the southern hemisphere has now been monitored over sufficiently long periods of time, both visually and by radio, that the list of major showers may be regarded as complete, with the possible exception of far

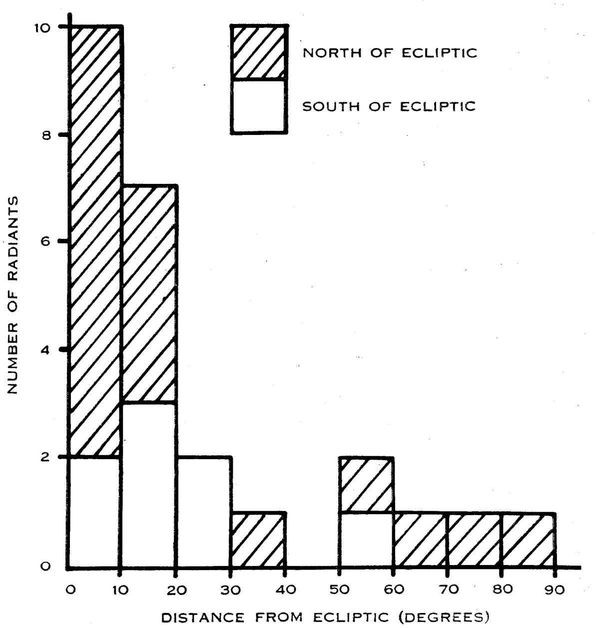

Fig. 5.—Distribution of the radiants of major showers, as a function of distance from the ecliptic.

southern periodic showers. It is therefore appropriate to review the distribution of the radiants of the major showers in ecliptical coordinates. For this purpose a table of showers has been compiled, comprising those shown in Figure 4 of the present paper, Class A showers listed by Ellyett and Roth (1955), and Table 78 of Lovell (1954) excluding the lost streams. This list consists of 25 showers, all of which have been detected by radio equipments. Their distribution as a function of distance from the ecliptic is illustrated in Figure 5. Seventeen radiants lie to the north of the ecliptic and only eight to the south, but in view of the close concentration to the ecliptic this apparent asymmetry between the two hemispheres is almost certainly not significant. The strong concentration to the ecliptic, together with a component extending to high inclinations, is strikingly reminiscent of the distribution of sporadic radiants derived in paper I.

Viewed in the light of the known disintegration of meteor streams, the similarity between these two distributions is both interesting and suggestive.

VI. Acknowledgments

This work forms part of the meteor research programme of the University of Adelaide. The project is financed jointly by the University of Adelaide, the Division of Radiophysics, C.S.I.R.O., and the Radio Research Board, C.S.I.R.O. The author is indebted to Dr. J. G. Davies of the Jodrell Bank Experimental Station, University of Manchester, for unpublished data relating to the October meteor activity, and to Dr. G. S. Hawkins of Harvard College Observatory for critical discussion.

VII. References

Browne, I. C., Bullough, K., Evans, S., and Kaiser, T. R. (1956).—*Proc. Phys. Soc. Lond.* **69**: 83.

Bullough, K. (1954).—*Jodrell Bank Ann.* **1**: 68.

Ellyett, C. D., and Keay, C. S. L. (1956).—*Aust. J. Phys.* **9**: 471.

Ellyett, C. D., and Roth, K. W. (1955).—*Aust. J. Phys.* **8**: 390.

Hawkins, G. S. (1956*a*).—*Astrophys. J.* **124**: 311.

Hawkins, G. S. (1956*b*).—*Mon. Not. R. Astr. Soc.* **116**: 92.

Hawkins, G. S., and Almond, M. (1952).—*Mon. Not. R. Astr. Soc.* **112**: 219.

Kaiser, T. R. (1955).—" Meteors." (Ed. T. R. Kaiser.) p. 119. (Pergamon Press: London.)

Krésak, L. (1955).—*Contributions of the Astronomical Observatory, Skalnaté Pleso* **1**: 9.

Levin, B. J. (1955).—" Meteors." (Ed. T. R. Kaiser.) p. 131. (Pergamon Press: London.)

Lovell, A. C. B. (1954).—" Meteor Astronomy." (Clarendon Press: Oxford.)

Weiss, A. A. (1955).—*Aust. J. Phys.* **8**: 148.

Weiss, A. A. (1957).—*Aust. J. Phys.* **10**: 77.

Whipple, F. L., and Hawkins, G. S. (1956).—*J. Met.* **13**: 236.