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Comet Arend-Roland (1956 h)

T. M. K. NEDUNGADI & J. V. NARAYANA
Kodaikanal Observatory, Kodaikanal

THE last bright comet which appeared and remained observable in the sky for a good many days was the ' Eclipse Comet ' of 1948. The announcement of the discovery of the comet (1956 h) aroused considerable interest as it had theoretical possibilities of being really bright. However, forecasts of brightness of comet are usually uncertain and the present comet also appears to have ultimately fallen into the group of comets that failed to become conspicuous.

The comet was first seen by Arend and Roland on a minor planet plate taken on 8 November 1956 at the Royal Observatory of Belgium, Uccle, as a tenth magnitude object; the discovery was, however, reported by them only on 19 November. The comet has since been found to be recorded on earlier plates taken at Sonnenberg and in Japan. At the time of discovery it was at a distance of nearly 3 A.U. from the sun and 2 A.U. from the earth and was located as a diffuse body just east of Alpha Trianguli and moving towards the south-west. During December 1956 and January 1957 it continued its motion south-westward through Pisces towards the sun and gradually brightened. Observers at Uccle Observatory noted night to night fluctuations in brightness over a two-magnitude range. By the beginning of February 1957 the comet brightened to magnitude 8 and developed a tail at least $\frac{1}{2}^{\circ}$ long. Position measurements were started soon after at numerous observatories in the world and the orbit of the comet was computed by several astronomers independently, with closely agreeing results. According to the ephemeris of the comet computed by Hasegawa at the Yamamoto Observatory, Japan (Table 1), the comet was expected to reach a magnitude of about zero in the second week of April. After its perihelion passage on 8 April at a distance of 29·7 million miles from the sun the comet was to move through Pisces into Triangulum again; on 22 April it was to be at about the same place in the sky where it was originally discovered. During the third week of April the comet was to pass between the earth and the sun and thereafter move rapidly northwards. Later on it was to fade while moving away from the sun through Perseus and Camelopardalis. Till the third week of April conditions were not to be favourable for observation of the comet in the northern hemisphere due to its proximity to the sun; but from about the end of April it was expected to be seen well in the north-western sky soon after the end of twilight.

Kodaikanal observations

The programme of study by the Kodaikanal Observatory consisted of: (i) Daily photography of the comet and the neighbouring star field with a 5 in. aperture and 3 ft. focal length camera fitted to the same equatorial as the main photoheliograph of the observatory; (ii) photographic and visual watch as also daily position measurements of the head of the comet by means of an 8 in. refractor; (iii) study of the spectrum of the comet with a two-prism low dispersion glass spectrograph used in conjunction with the 20 in. Bhavnagar reflector of the observatory; and (iv) visual sketching and continuous observations by a 6 in. refractor and a big

TABLE 1 — EPHEMERIS OF COMET AREND-ROLAND (1956 h)*

Date	Right ascension 1950·0		Declination 1950·0		Magnitude ($m = 5{\cdot}1 + 5 \log \Delta + 10 \log r$)	Distance of the comet in astronomical units from		Comet's sky co-ordinates relative to the sun	
						Earth Δ	Sun r	Right ascension	Declination
	hr.	*min.*	*deg.*	*min.*				*hr.*	*deg.*
11 February 1957	00	18.2	−02	13	7·9	1·939	1·366	+02.7	+12·2
21 February 1957	00	21.6	−04	11	7·2	1·899	1·180	+02.1	+06·8
3 March 1957	00	26.0	−06	13	6·3	1·818	0·983	+01.5	+00·7
13 March 1957	00	30.9	−08	30	5·1	1·683	0·776	+01.0	−05·5
23 March 1957	00	35.6	−11	08	3·4	1·475	0·561	+00.5	−12·0
2 April 1957	00	39.6	−13	05	1·1	1·156	0·368	−00.1	−17·9
12 April 1957	00	52.7	−03	34	−0·2	0·773	0·338	−00.5	−12·2
17 April 1957	01	19.1	+12	15	0·1	0·598	0·412	−00.3	+01·9
22 April 1957	02	01.4	+32	35	1·0	0·572	0·511	00.0	+20·5
27 April 1957	02	59.7	+48	41	2·0	0·643	0·618	+00.7	+35·0
2 May 1957	04	05.9	+57	45	3·1	0·767	0·726	+01.5	+42·5
7 May 1957	05	08.7	+61	51	4·1	0·913	0·832	+02.2	+45·1
12 May 1957	06	05.5	+63	19	4·9	1·066	0·936	+02.8	+45·2
17 May 1957	06	41.0	+63	33	5·7	1·219	1·036	+03.1	+44·3
22 May 1957	07	12.3	+63	15	6·3	1·371	1·135	+03.3	+42·9
1 June 1957	07	57.9	+62	07	7·4	1·661	1·324	+03.4	+40·1
11 June 1957	08	30.4	+60	54	8·3	1·930	1·504	+03.7	+37·8
21 June 1957	08	56.4	+59	49	9·0	2·179	1·676	+03.0	+36·4
1 July 1957	09	18.6	+58	54	9·7	2·405	1·843	+02.6	+35·7

*Ephemeris computed by T. Hasegawa, Yamamoto Observatory, Japan.

binocular of magnification 7 and aperture 2 in.

A daily watch was kept throughout the second half of April 1957. The comet was seen for the first time on 29 April between 19.30 and 20.15 hr. I.S.T. at low angles in the N.N.W. sky. The brightness of the head was then judged to be of fourth magnitude. It had a small condensed head and a rapidly diverging tail about 7° long. The extent of the tail and the brightness markedly decreased even by the second day. Adverse atmospheric conditions at Kodaikanal, coupled with the low altitude of the comet and the waxing moon of the evenings, made subsequent systematic recording of the comet difficult. Between 29 April and 16 May visual observations could be made on 11 days and on 6 of these days photographs were also taken using Ilford Selochrome or Kodak P1200 plates. Kodaikanal observations covered practically the entire period the comet traversed the constellation Camelopardalis. Later the comet, though weak, was still in a convenient position for telescopic studies but bad weather did not permit further work.

Position of the comet — The right ascension and declination of the nucleus of the comet determined from the photographic and visual records are given in Table 2. Fig. 1 gives the track of the comet as observed at Kodaikanal. The computed positions during the period of observations taken from Table 1 are also plotted for comparison. It can be seen that the computed positions agree generally with observed positions, but for about 0·2° difference in declination. The difference between the computed and observed positions is markedly seen when a seventh magnitude star (GC 5160) in the Camelopardalis Constellation lying outside the computed track actually coincided with the nucleus of the comet on the photograph taken on 2 May.

TABLE 2 — POSITION OBSERVATIONS OF THE COMET MADE AT KODAIKANAL OBSERVATORY

Date	Mean time (U.T.)		Right ascension		Declination	
	hr.	*min.*	*hr.*	*min.*	*deg.*	*min.*
30 April 1957	14	27	03	47	56	06
1 May 1957	14	53	04	00	57	25
2 May 1957	14	23	04	14	58	40
4 May 1957	14	35	04	39	60	25
5 May 1957	14	53	04	52	61	15
6 May 1957	14	45	05	04	61	48
7 May 1957	14	57	05	16	62	16
9 May 1957	14	19	05	36	62	55
10 May 1957	14	15	05	49	63	13
16 May 1957	14	53	06	37	63	43

Brightness and structure — Among the photographs taken, those of 2, 6 and 7 May were reasonably good and are reproduced in Fig. 2. Exposures of 40-45 min. had to be given to record these pictures with the 5 in. aperture camera — an unusually long exposure compared to that given while photographing other naked-eye comets. The Comet Arend-Roland could be seen at Kodaikanal by naked eye with difficulty till 6 May only and it was later followed through

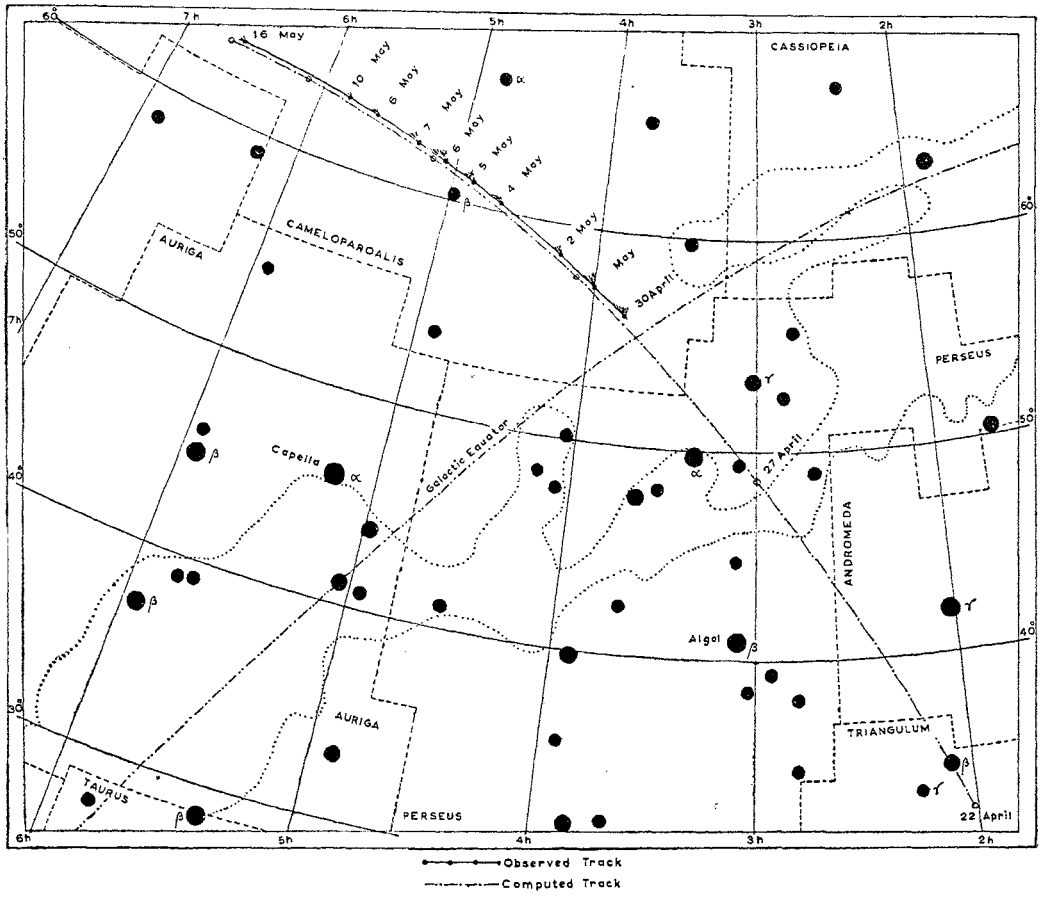

FIG. 1 — TRACK OF COMET AREND-ROLAND (1956 h)

telescopes and binocular. Visual estimates show that the brightness rapidly decreased from about fourth magnitude to below sixth magnitude between 29 April and 6 May. The brightness of the head as estimated from the neighbouring stars on the photographic plates was 1-2 magnitudes less. The difference is easily understood because the visual magnitudes include the total effect of the head while photographic magnitudes are likely to refer primarily to the nucleus. Further, photographic plates vary in response to light of different colours from that of the eye.

The theoretically predicted brightness of the comet is about 2 magnitudes higher than visual estimates (Table 1). For a comet which shines only by the reflected light from the sun the apparent luminosity would vary inversely as the square of its distance from the earth and from the sun. If I is the luminosity of a comet at distance r from the sun and Δ from the earth and I_0 the standard luminosity at unit distance from both bodies, I is given by the expression

$$\frac{I}{I_0} = \frac{1}{r^2\Delta^2}$$

Generally for comets, an empirical expression of the type

$$\frac{1}{r^n\Delta^2}$$

is employed where n is 3, 4, 5 or 6. For calculating the probable luminosities (Table 1) a fourth power law for r has been used. Even after allowing for uncertainties in

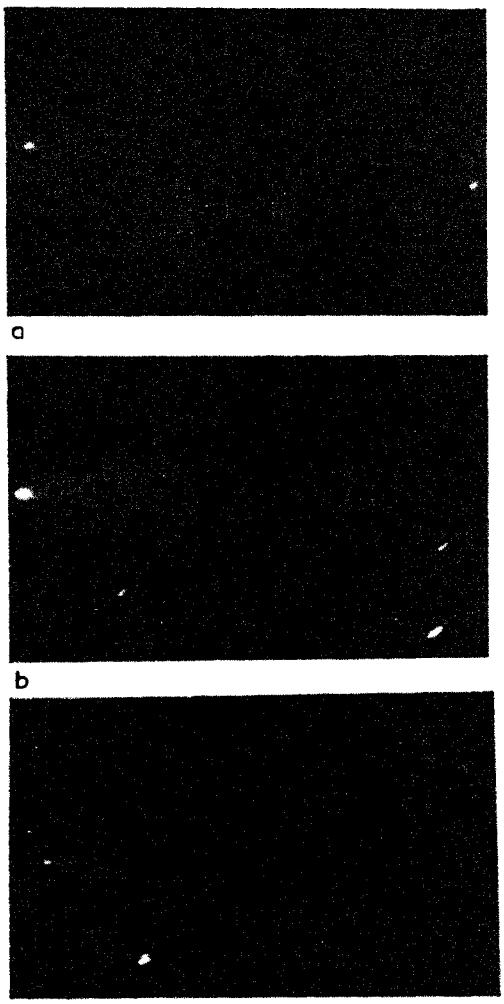

FIG. 2 — PHOTOGRAPHS OF COMET AREND-ROLAND [(a) 2 May: 19.30-20.15 hr. I.S.T.; (b) 6 May: 19.55-20.35 hr. I.S.T.; (c) 7 May: 20.05-20.50 hr. I.S.T.]

making correct visual estimates under the particular observing conditions at Kodaikanal, it is believed that the actual brightness was significantly less than what was anticipated theoretically. Our observations, therefore, indicate that a lower power, namely 3 or 2, would be more appropriate for r in the case of the Comet Arend-Roland.

The nebulous coma round the nucleus, so characteristic of most of the bright comets, was practically absent with this comet on most of the days of observation; but on 29 and 30 April a slightly hairy and irregular structure was noticed for the boundary of the head. No rapid fluctuations occurred in the brightness of the head.

The tail of the comet was symmetrically diverging and straight with condensation lines of luminous matter along its length of the type seen in Fig. 2(b). No noticeable changes in the structure were detected during the period of study. The visual length of the tail rapidly decreased from about 7° on 29 April to less than a degree on 16 May. A peculiar feature of the tail was its great divergence, the angle being about 50° on the photograph taken on 6 May, and in this respect it resembles the Morehouse Comet of 1908.

Spectroscopy — Attempts were made to record the spectrum of the comet's head with the spectrograph fitted to the 20 in. reflector. The same photographic plate was kept in position and exposed daily when the image on the slit was bright enough for easy guiding. The first spectrum plate was exposed in this manner for 3 hr. 19 min. from 30 April to 3 May. A second plate was exposed for a total period of 7 hr. 17 min. from 4 to 10 May. No significant spectrum was recorded on either of the plates due to the feeble light.

Acknowledgement

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