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TERMINAL SYNCHRONES IN THE TAIL

OF COMET 1965f




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December 1965


Supported by
NASA Grant NsG-142-61

# TERMINAL SYNCHRONES IN THE TAIL OF COMET 1965f

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*Positional measurements were made of six synchrones in the tail of Comet Ikeya-Seki, 1965f. These synchrones were emitted during a 43-hour period beginning 22 hours after perihelion passage. During the observed interval, 26 October to 1 November 1965, the synchrones moved outward from the coma with constant velocities between 52 and 87 km/sec.* author

## INTRODUCTION

After passing perihelion on 21 October 1965, Comet Ikeya-Seki, 1965f developed a long tail which displayed several well-defined, ray-like structures. These terminal synchrones were photographed at the New Mexico State University Observatory between 26 October and 5 November 1965. Figure 1 shows the synchrones as they appeared on 28 October.

## METHOD

The position angles of the synchrones were determined by measuring the original negatives with a Mann measuring machine, and have a mean probable error of $\pm 0^{\circ}.36$. The end points of the synchrones were measured to within $\pm 0^{\circ}.1$ by projecting the original negatives onto an *Atlas Ecliptical*. On two dates, however, it was found to be more practical to measure the positions of the two faintest synchrones from

high contrast photographic prints. The angular separation between the coma and the synchrones was converted to astronomical units using supplementary information contained in IAU *Circulars* 1930 and 1931.

The velocities and dates of emission of the synchrones were calculated using the method of least squares. The uncertainties involved were quite small; the velocities of the synchrones were found to within ±2% (p.e.), and the times of emission were uncertain by about ±10 minutes (p.e.).

## RESULTS

Six synchrones were observed, and are numbered in order of ejection. The south ends of all the rays, as well as the north ends of numbers 4 and 6, were measured. Since the other four synchrones did not extend completely across the tail, as shown in Figure 1, it was not possible to make accurate measurements of their north ends. The first two synchrones faded very rapidly after 28 October; consequently, only two positions were obtained. The other four showed no great change in appearance as they moved away from the head of the comet.

Visual observations (Solberg and Minton, 1965) show a great increase in the brightness of the comet about a week before perihelion, indicating considerable activity as the comet approached the sun. This activity almost certainly continued after perihelion passage. Photographs by Moriyama and others at the Tokyo Observatory (Marsden, 1965) show a synchrone-like brightening which appeared in the tail approximately 90 minutes prior to perihelion

passage. The Japanese astronomers also observed disintegration of the comet head, beginning 25 minutes before perihelion passage. Visual observations by observers using large apertures (IAU *Circular* 1937) show a further splitting of the comet's nucleus, which probably took place about 28 October. This activity before and after perihelion passage is probably related to the formation of the synchrones.

Figure 2 indicates four separate expulsions of material shortly after perihelion, assuming the velocities of the synchrones were constant throughout their lifetimes. It is interesting to note that both ends of synchrones 4 and 6 were emitted at nearly the same time. This is consistent with the theory that synchrones are composed of different sized particles which undergo different forces of repulsion (Wurm, 1963).

Velocities between 52 and 87 km/sec were measured. These values agree well with the velocities of synchronous structures in the tail of Comet 1957d (McClure and Liller, 1958). During the observed interval, however, the velocities of the 1965f synchrones were constant, unlike the 1957d synchrones which underwent accelerations of approximately 2.4 $cm/sec^2$. When synchrones move outward with a constant velocity, the tail is considered to be composed of dust (Wurm, 1963).

The position angles of the synchrones increased slightly, as shown in Table 2, because they maintained the same orientation to the edges of the tail as they moved into the curved portion of the tail.

The constant velocities of the synchrones indicate that the sum of the inward radial forces balanced the sum of the outward radial

forces. However, the nature and magnitude of many of these forces are unknown; in addition to the well-known solar gravitational and electromagnetic radiation fields, the less understood solar corpuscular radiation, solar and interplanetary magnetic fields and the interplanetary medium could also have been involved. These forces would interact, to a varying extent, with the particles of the tail, and would, therefore, contribute to the equations of motion of the synchrones.

ACKNOWLEDGEMENTS

I would like to thank B. A. Smith and T. P. Pope who obtained most of the photographs used in this study. I am also indebted to R. B. Minton, T. A. Smith, and J. E. Womack, whose photographs were very useful.

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Figure 1. Photograph of the synchrones on 28 October 1965, from 1155-1205 UT. North is upward, and east is to the left. Synchrones 1 and 2 are faintly visible near the right edge of the photograph; synchrone 4 is the most prominent ray near the center. Photograph by R. B. Minton.

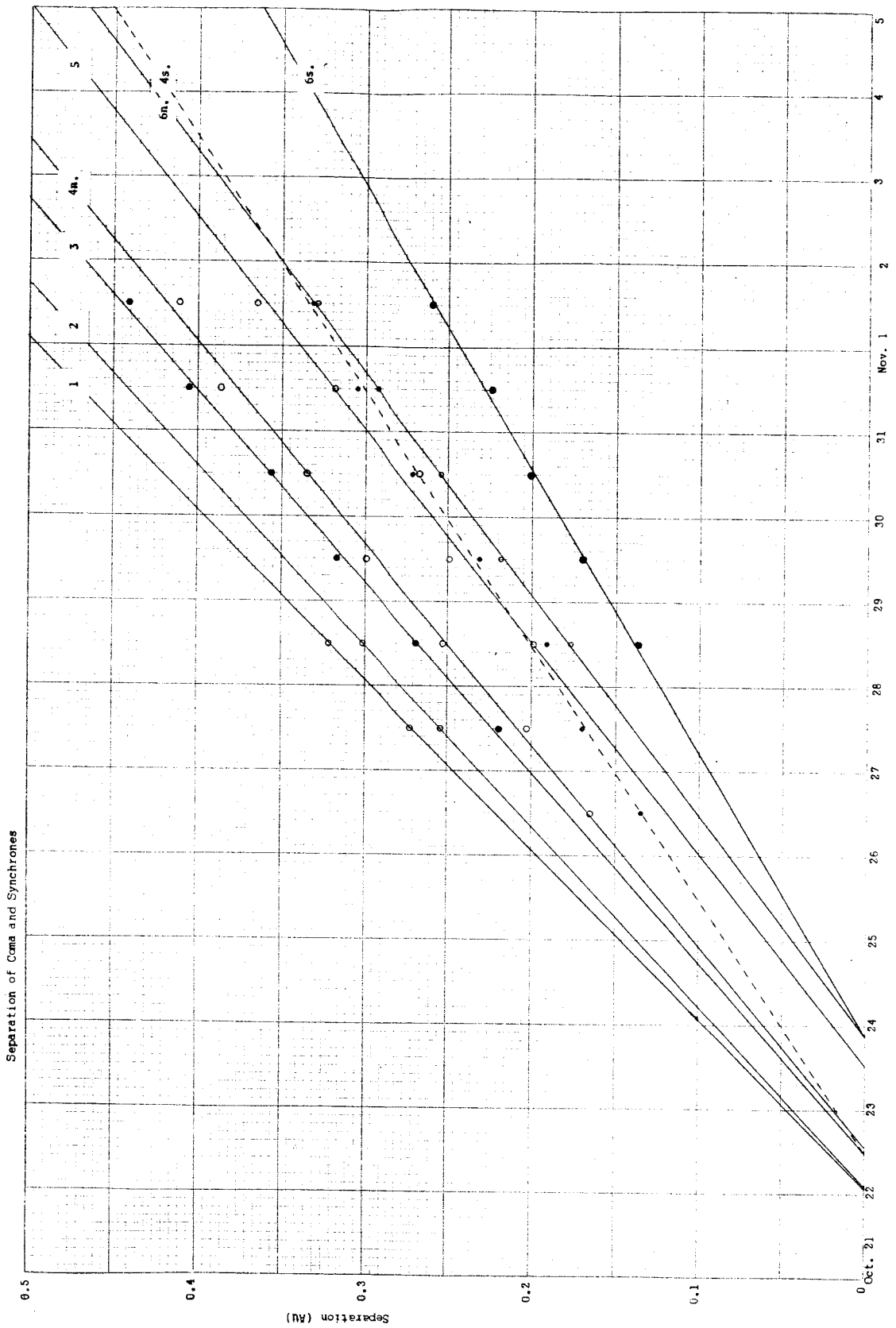
Separation of Coma and Synchrones
Separation (AU)
0.5
0.4
0.3
0.2
0.1
0
Oct. 21
22
23
24
25
26
27
28
29
30
31
Nov. 1
2
3
4
5
1
2
3
4n.
5
6n.
4s.
6s.

TABLE I

VELOCITIES AND DATES OF EXPULSION OF SYNCHRONES

| Synchrone | Limiting Dates | Velocity (km/sec) | P.E. | Date of Expulsion | P.E. | Number of Observations |
|---|---|---|---|---|---|---|
| 1 | 27 Oct-28 Oct | 86.6 | ---- | Oct. 22.08 | ---- | 2 |
| 2 | 27 Oct-28 Oct | 81.4 | ---- | 22.10 | ---- | 2 |
| 3 | 27 Oct-1 Nov | 77.0 | ±0.9 | 22.49 | ±0.002 | 6 |
| 4 n. | 26 Oct-1 Nov | 57.8 | 0.9 | 22.50 | .002 | 7 |
| s. | 26 Oct-1 Nov | 73.2 | 1.2 | 22.57 | .003 | 7 |
| 5 | 28 Oct-1 Nov | 69.4 | 2.4 | 23.52 | .004 | 5 |
| 6 n. | 28 Oct-1 Nov | 51.8 | 1.0 | 23.87 | .002 | 5 |
| s. | 28 Oct-1 Nov | 66.7 | 0.3 | 23.88 | .001 | 5 |

TABLE II

POSITION ANGLES OF THE SYNCHRONES

AND PROBABLE ERRORS

| Synchrone | 1965 October 26 | 27 | 28 | 29 | 31 | November 1 |
|---|---|---|---|---|---|---|
| 3 | ---- | 272°.6 | 273°.2 | 275°.1 | 276°.6 | 277°.0 |
| | | 0.2 | 0.4 | 0.5 | 0.4 | 0.4 |
| 4 | 268.5 | 272.2 | 270.7 | 269.0 | 272.5 | 273.2 |
| | 0.7 | 0.4 | 0.1 | 0.3 | 0.4 | 0.4 |
| 5 | ---- | ---- | 264.4 | 267.8 | 267.5 | 269.9 |
| | | | 0.2 | 0.4 | 0.2 | 0.4 |
| 6 | ---- | ---- | 260.4 | 263.4 | 262.3 | 263.6 |
| | | | 0.5 | 0.2 | 0.4 | 0.5 |