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Photographic Observations of the Large Scale Features of Comet Halley

By

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Abstract

Thirteen representative pictures of Comet Halley which have been taken during its 1985/1986 apparition are presented. Some discussions on peculiar features seen in the tail are given.

1. Introduction

The approach of Comet Halley(1982i) to the sun in 1986 provided excellent opportunities to observe the structure of its nucleus and the evolutional change of the coma and the tails, although the observations from the earth were impossible during the period of its conjunction with the sun. Many worldwide cooperative efforts by groundbased and space observations have been performed during the interval of its 1985/1986 apparition under the coordination of the International Halley Watch(IHW). We carried out photographic observations of Comet Halley, as a part of the ground-based network observations in IHW, at the Ouda station (135°52′E, 34°28′N) of the Department of Astronomy of Kyoto University on 60 nights during the period from August 1985 through April 1986, and also at the Hida Observatory (137°13′E, 36°15′N) of Kyoto University on 23 nights for the interval from October 1985 to December 1986. In this report, we present thirteens of representative pictures taken at different epochs in the evolution of Comet Halley, and delineate some notable peculiar features detected in the tail.

2. Observations

The instrument used at the Ouda station is the 40/70/120 cm Schmidt camera(Imagawa et al. 1977). The plate scale is 172 arcsec mm^{-1} covering a field of 7° in diameter. The emulsions used are IIa-O, 103a-O, 103a-D and 103a-F plates hypersensitized by the forming gas baking. The red images of the comet were taken with 103a-F through a glass filter Y-50 and/or with 103a-D and 103a-F through a R-60 filter. The exposure time ranges from 5 to 30 minutes. The manual guide of the telescope for tracking the movement of the comet against the background sky during the exposure

time was performed. The plate was developed with the D-19 liquid at 20°C for 5 minutes. Throughout the course of our observations, we obtained about 60 plates with the use of the Ouda instrument.

At the Hida Observatory, the comet was photographed with the 60cm reflector(f= 330 cm) and the 14cm astrocamera(f=70 cm). The photographic plates of 103a-O and 103a-E at the prime focus of the reflector cover a field of 1.3°×2°, and the plate scale is 60 arcsec mm^{-1}. The exposure time was between 10 and 20 minutes, throughout of which we relied on the track rate of the telescope which was set from the ephemerides available for the movement of the comet against the background sky. The 103a-O and 103a-E plates taken by the 14cm astrocamera mounted on the reflector have a plate scale of 300 arcsec mm^{-1}, and cover a field of 9.6°×6.5°. An acetate filter(SP-8) was used when the comet was photographed with the 103a-E plate. The development of these plates was made with the D-19 liquid at 20°C for 5 minutes. About 100 plates were taken at the Hida Observatory using both instruments.

3. Photographic features in some epochs

Among 160 photographs of Comet Halley obtained at both stations, thirteens of selected pictures taken in some different epochs of its evolution are illustrated in Figure 1 through 8b. Table 1 is the list of selected pictures which gives the observed date and time(UT), exposure time, emulsion and filter.

The picture of Comet Halley that is the first in our observation was taken on September 17, 1985, and it is shown in Figure 1, in which an arrow indicates the position of Comet Halley. Since the coma has already been recognized before our first observation, the image is non-stellar. An abrupt change of the direction of tail has been observed on November 16, 1985. The comparison of Figure 2a with Figure 2b gives evidence that the direction of tail with respect to the coma changed about 50° from PA =205° to 255 within 3 hours, and that the ejection of matter from the head was not continuous for this time interval. If the change of the direction of tail is due to the rotation of the comet, its rotational period can be estimated to be 22 hours. However, Millis and Schleicher(1986) evaluated from the groundbased photometry of Comet Halley the rotational period of the comet to be near 7.4 days, and Sekanina and Larson(1986), from the morphological study of Comet's coma, to be near 2.2 days. Their values are too large to explain the change of tail direction we observed.

The tail developed at the beginning of December 1985, and five rays appeared on December 5, 1985(Figure 3). These rays formed within the inclination of 30°~40° relative to the tail axis, and the longest one can be traced to more than 1° or 2.8×10^6 km from the head. The width of individual ray is less than 3×10^4 km, which is nearly the same as those observed in other comets (Ip and Axford 1983). Elongated Type I and II tail are detectable in the pictures of December 12 (Figures 4a and 4b). Type I tail is longer than Type II.

One of the peculiar features seen in the tail is a kink (or disconnection event; DE) observed on January 10, 1986 (Figures 5a and 5b) which is similar to that appeared on December 31, 1985. A comparison of our January 10 picture with that observed at the

Table 1. List of selected pictures of Comet Halley

Date	Time (UT)	Exposure (minutes)	Emulsion	Filter	Instr.	Figure No.
1985 Sept 13	18 : 20	30	103a-D	Y-50	Schmidt*	1
Nov 16	13 : 26	20	103a-O		60L**	2a
Nov 16	16 : 00	12.75	103a-O		60L	2b
Dec 5	09 : 40	20	103a-O		60L	3
Dec 12	09 : 15	20	IIa-O		Schmidt	4a
Dec 12	09 : 54	30	103a-F	Y-50	Schmidt	4b
1986 Jan 10	09 : 20	5	IIa-O		Schmidt	5a
Jan 10	09 : 35	5	103a-F	Y-50	Schmidt	5b
Apr 7	18 : 14	20	103a-E		60L	6a
Apr 13	14 : 35	20	103a-O		14cmF5***	7a
Apr 13	16 : 25	30	103a-E	SP-8	14cmF5	7b
Apr 29	11 : 59	15	IIa-O		Schmidt	8a
Apr 29	12 : 26	30	103a-D	Y-50	Schmidt	8b

*Schmidt:the 40/70/120cm Schmidt camera
**60L:the 60cm reflector
***14cmF5:the 14cm astrocamera

Uchinoura station (Halley's Comet 1985–1986: A Photographic Documentary 1986) about 66 minutes after our observation indicates that the position of the kink on the sky plane did not change while the head advanced about 1.97×10^{-2} degrees during this time interval. The angle between the comet-sun vector and the line of sight at $10^{h}26^{m}$UT on January 10 was 47.6°. By assuming that the Type I tail elongates along the comet-sun vector, and by neglecting the aberration angle between the tail vector and the comet-sun vector (which is usually evaluated to be less than 5°, according to Brandt (1968)), the velocity of the kink propagating along the tail at the distance of 3×10^{6} km from the center of head is estimated to be 27 kms^{-1}. Tomita and Saito (1987) studied the speed of this kink with the use of many pictures taken at various stations in the world. It gradually increases and amounts to about 200 kms^{-1} at the distance of 2×10^{8} km from the head.

An ultimate cause of such a disturbance in the tail can usually be searched out in the activity on the solar surface. However, the solar activity was very low during the period of 1985/1986 apparition of Comet Halley: That is, the monthly sunspot relative numbers in December 1985 and January 1986 were 17.3 and 2.5, respectively. No flares have been reported in Solar Geophysical Data for the period from December 20 through January 12. Furthermore the helium enhanced region which is usually regarded as the source place of the solar wind was not visible on the Kitt Peak 10830 Synoptic Chart of the Sun (Solar Geophysical Data 1986) except for the polar regions. Thus we failed to find any causes of this feature on the solar surface. However, Tomita and Saito (1987) suggested the cause of this feature as well as a kink observed on December 31 to be the penetration of high speed solar wind into the comet tail.

An extended coma in the picture of April 7, 1986 is noticeable (Figure 6a). In order

to study the structure in the coma, following procedures were made for the image on the original plate. The coma in solar side shows remarkable enhancement in brightness, while that in anti-solar side, not enhanced. Here we define the coma in the anti-solar side as the normal coma. The intensity in the normal coma decreases with distance along the radius from the center of coma. A processed picture was produced by subtracting the half intensity in the normal coma from the observed intensity of the original image at each points in the coma. Thus a fan-like feature is clearly visualized in the processed picture (Figure 6b). It extends about 4×10^4 km in the solar side with an angle of $\pm60^\circ$ relative to the tail, and is similar to the mass ejecting feature from the nucleus observed on April 23 by A'Hearn et al. (1986).

Figures 7a and 7b show respectively the pictures of blue and red images of Comet Halley taken on April 13, 1986. These were photographed through thick haze, because of low altitude of the comet. However the difference between the ion and the dust tails is clearly visible in the isophotos of both images given in Figures 7c and 7d. Similar difference between both tails is also exhibited in the pictures of April 29 (Figures 8a and 8b) and in their isophotal maps (Figures 8c and 8d).

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References

A'Hearn, M. E., Hoban, S., Birch, P. V., Martin, R., and Klinglesmith, D. A. 1986, Nature, **324**, 649.

Brandt, J. C. 1968, Ann. Rev. Astron. Astrophys. **6**, 267.

Halley's Comet 1985–86: A Photographic Documentary, 1986, ed. Astronomical Society of Japan (University of Tokyo Press, Tokyo) p. 44.

Imagawa, F., Kawai, S., Tsujimura, T., Ohtani, H., Hirata, R., 1977, Memoirs of the Faculty of Science, Kyoto University, Series of Physics, Astrophysics, Geophysics and Chemistry, Vol. XXXV, No.1, Article 11, 185.

Ip, W.-H. and Axford, W. I., 1982, in Comets,ed. Laurel L. Wilkening (The University of Arizona Press, Arizona) p. 588.

Millis, R., and Schleicher, D. G., 1986, Nature, **324**, 646.

Sekanina, Z. and Larson, S. M. 1986, Nature, **321**, 357.

Tomita, K. and Saito, T. 1987, in Proc. 8th Colloquium on Solar System Science, ed. M. Oda (Institute of Space and Astronautics Science, Tokyo), p. 36(in Japanese).

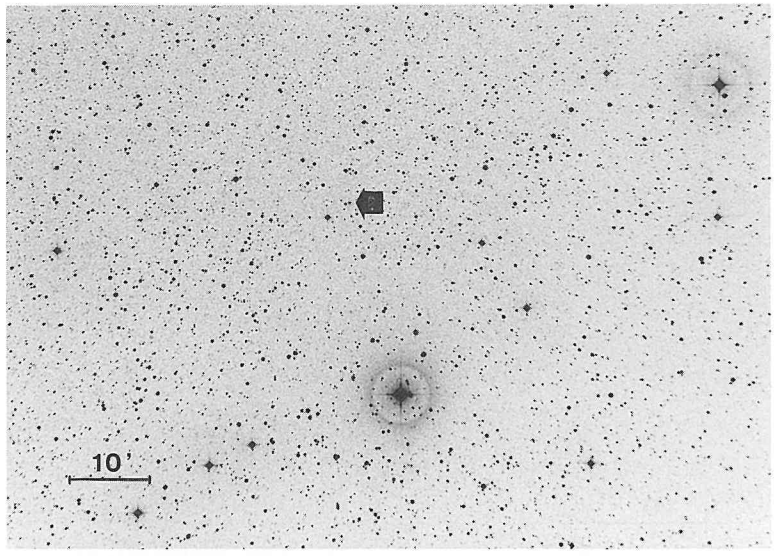

Figure 1: The first observation of Comet Halley at the Ouda station. An arrow indicates the position of the comet. North is top in all pictures, except for Figures 7a-7d, and the scale is given in every picture.

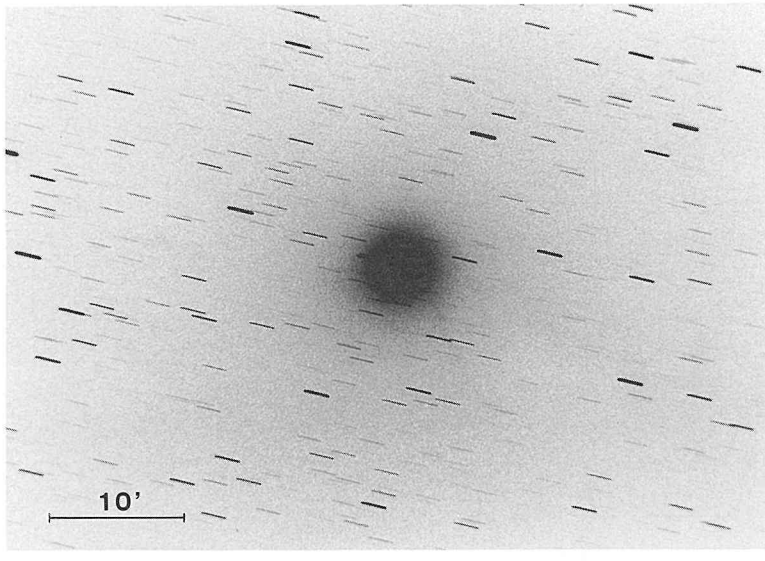

Figure 2a: The change of the direction of tail observed on November 16, 1985. Observation at $13^{h}26^{m}$UT.

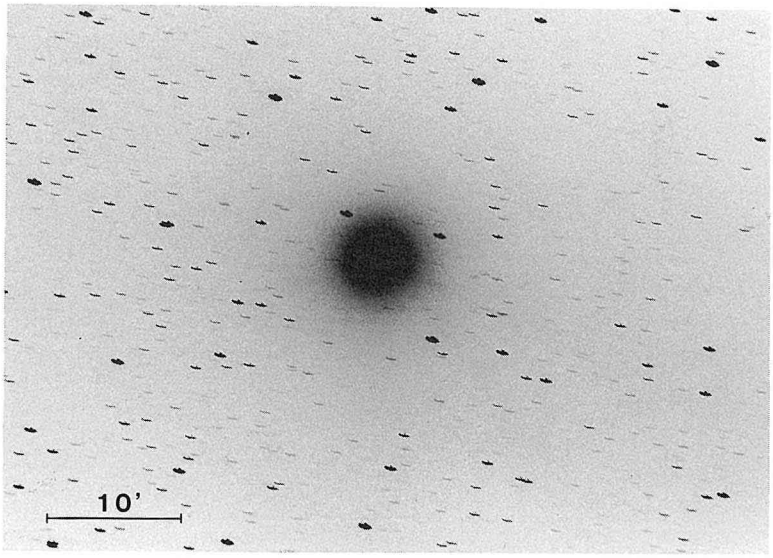

Figure 2b: Observation at 16^h00^mUT.

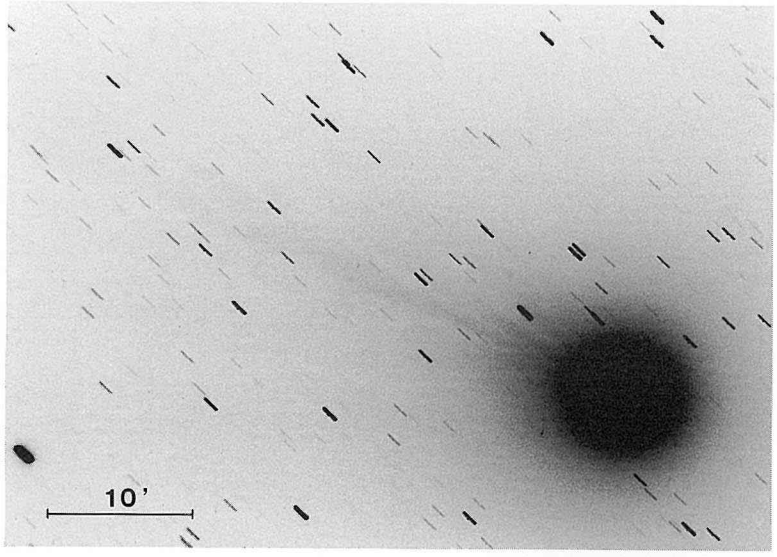

Figure 3: Tail rays on December 5. Five rays are visible, see text.

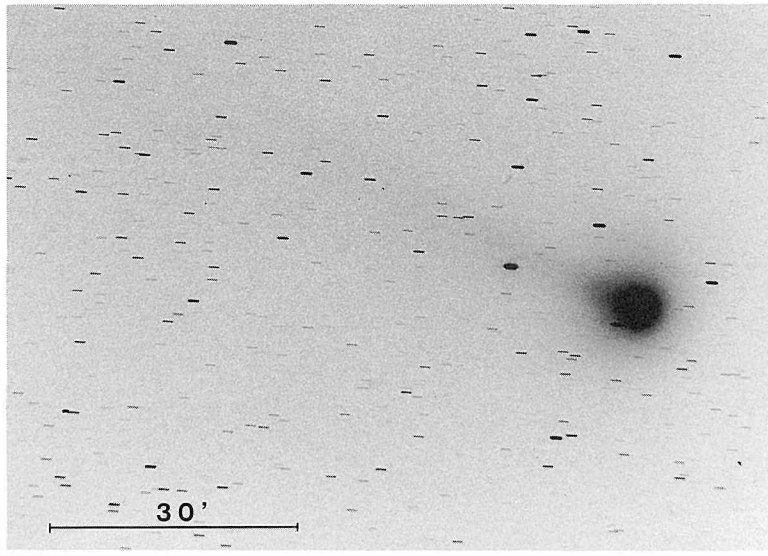

Figure 4a: Elongated Type I and II tails observed on December 12. Blue image.

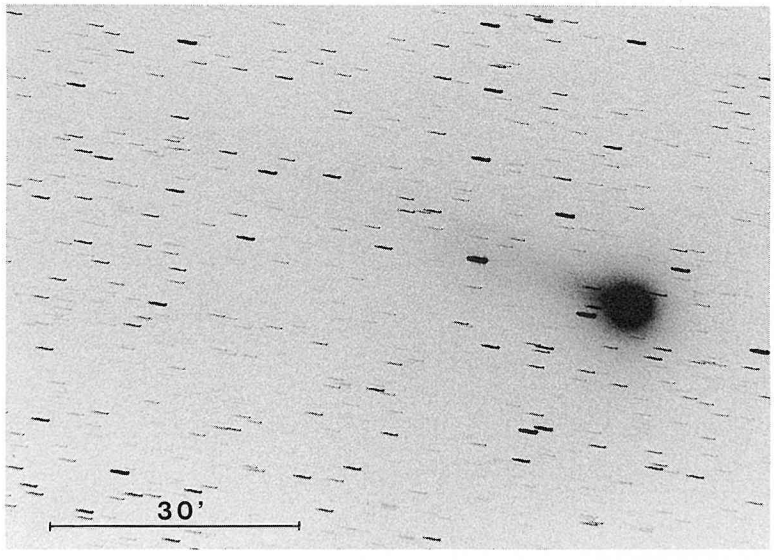

Figure 4b: Red image.

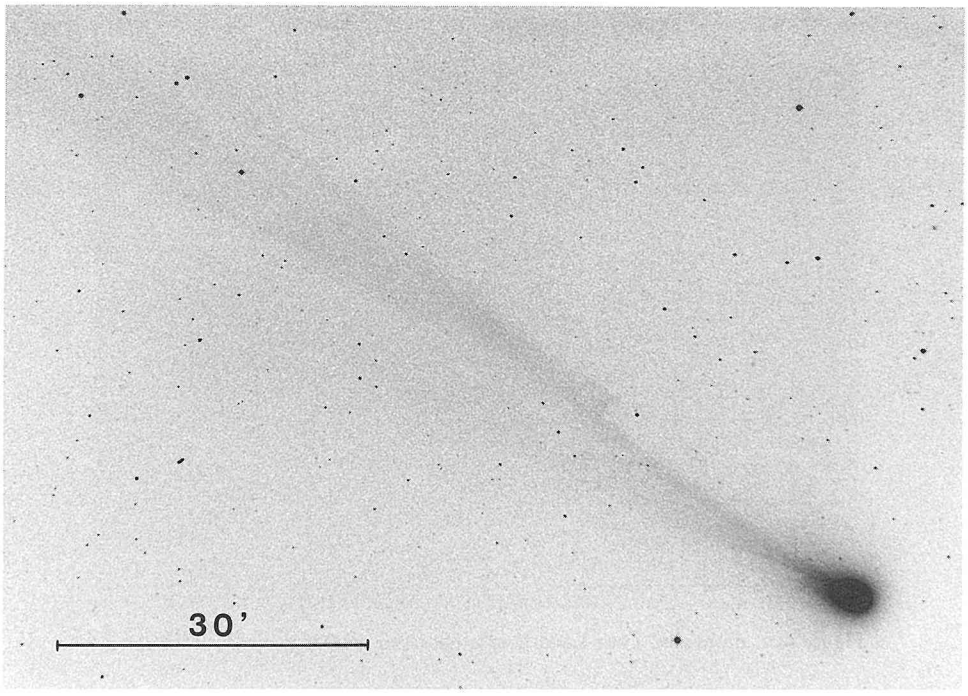

Figure 5a: A kink in the tail observed on January 10. Blue image.

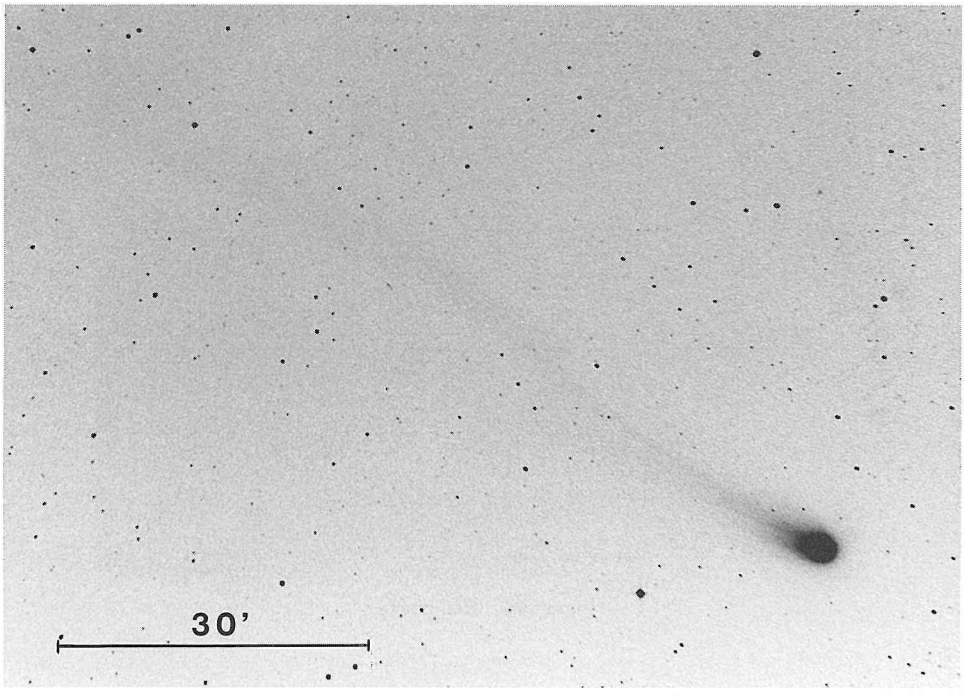

Figure 5b: Red image.

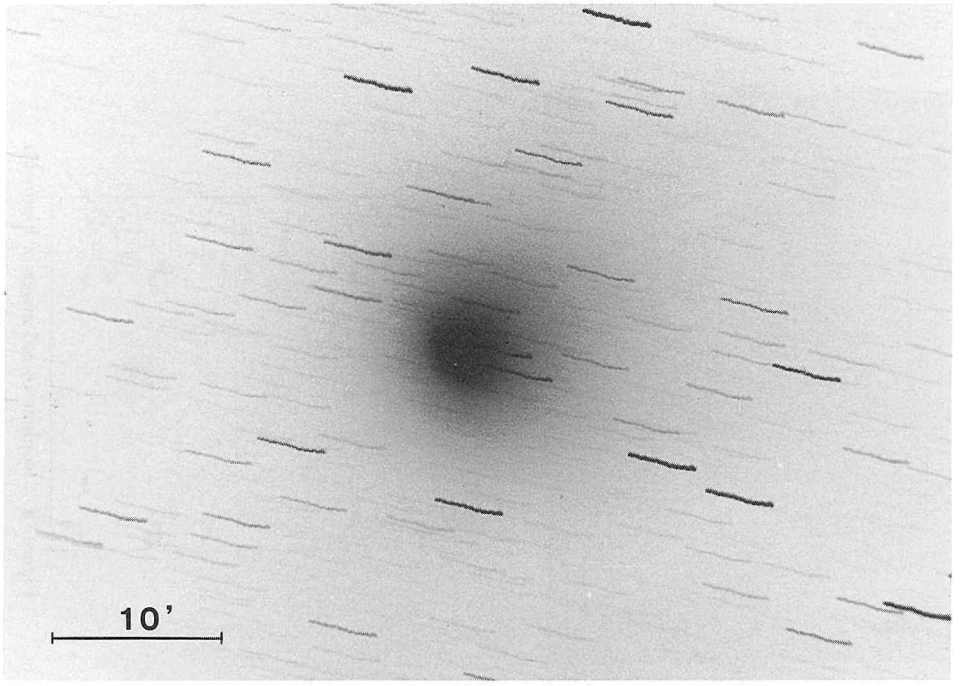

Figure 6a: Extended coma observed on April 7.

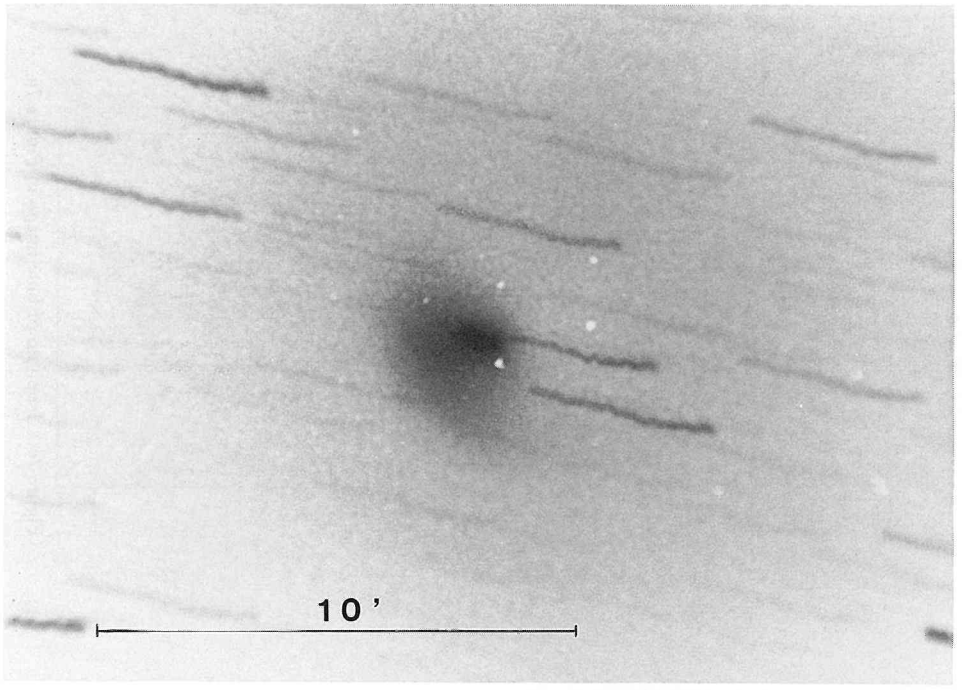

Figure 6b: The processed picture to enhance a fan like feature. Explanations are given in the text.

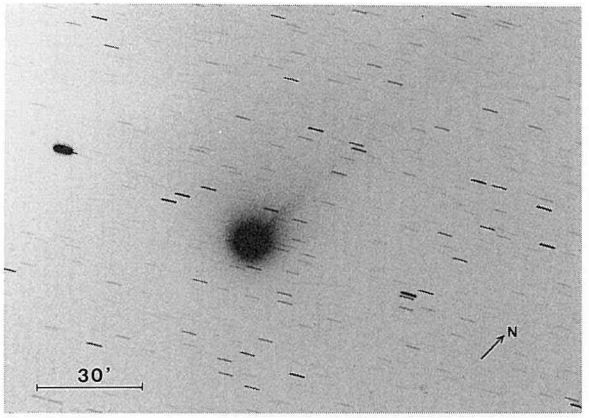

Figure 7a: Blue image of Comet Halley observed on April 13.

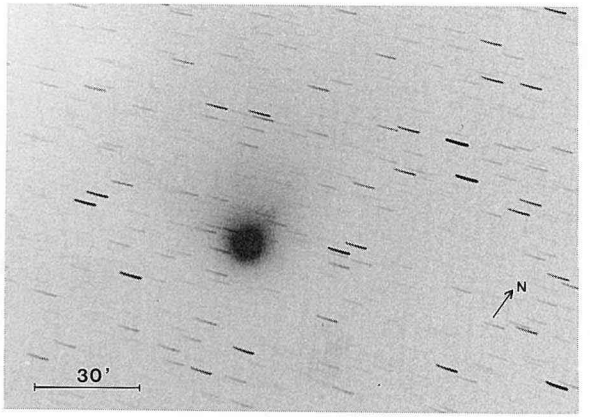

Figure 7b: Red image.

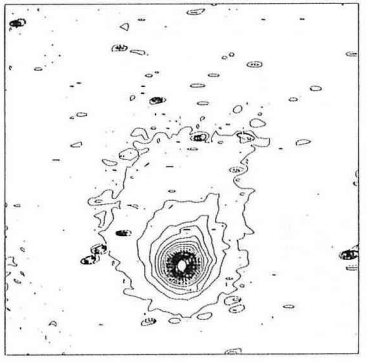

Figure 7c: Isophoto of blue image of Figure 7a.

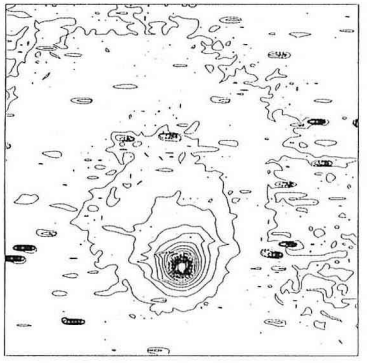

Figure 7d: Isophoto of red image of Figure 7b.

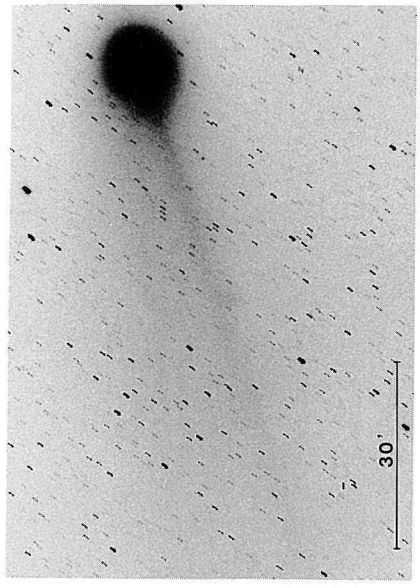

Figure 8a: Blue image of Comet Halley observed on April 29.

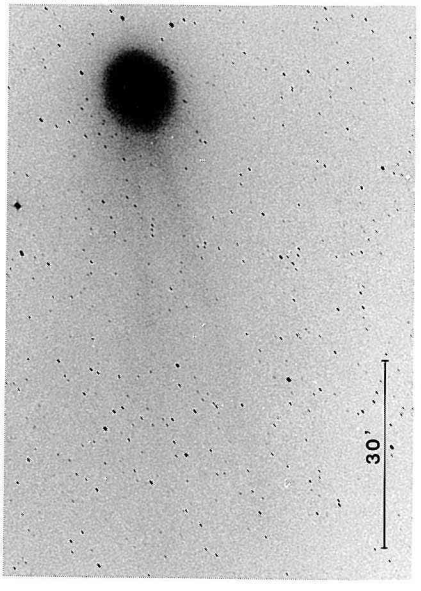

Figure 8b: Red image.

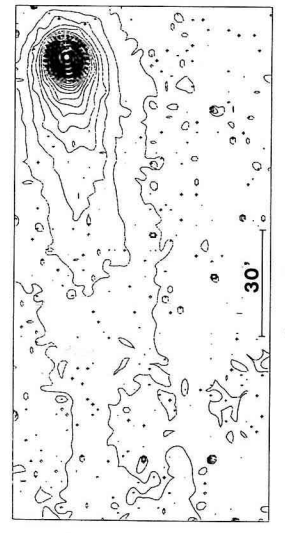

Figure 8c: Isophoto of blue image of Figure 8a.

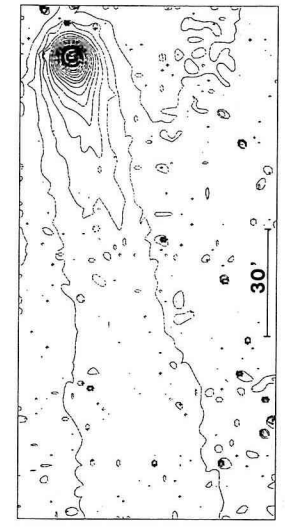

Figure 8d: Isophoto of red image of Figure 8b.