Publ. Natl. Astron. Obs. Japan Vol. 4, 331-342 (1990)

PHOTOGRAPHIC OBSERVATIONS OF COMET IRAS-ARAKI-ALCOCK 1983VII

By

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(Received April 20, 1990)

Abstract

Comet IRAS-Araki-Alcock 1983VII (=1983d) was observed with the 50-cm Schmidt telescope at the Dodaira Observatory. 29 photographic plates were obtained from May 7 through May 11 1983. On May 12, two plates were taken with the 105 cm Schmidt telescope at the Kiso Observatory. This paper presents reproductions of 18 representative plates of high quality along with isophotes in order to show the unique morphological variation of the coma during this period. The interrelation between the coma morphology and the nucleus activities is discussed. The existence of ion tail is also noted.

Key words: Comets; Comet IRAS-Araki-Alcock 1983VII; Photographic atlas; Morphology of comets

1. Introduction

Comet IRAS-Araki-Alcock 1983VII(=1983d) was discovered as a fast moving object by IRAS on April 25, 1983. Two independent discoveries were carried out by G. Araki on May 3.6 UT, and by G. E. D. Alcock on May 3.9 UT, respectively (IAU Circular No. 3796, 1983). Because of its small geocentric distance of 0.0313 A.U. on May 11.5 UT, this comet provided us a unique opportunity to observe the near-nucleus phenomena, and may be a first comet of which the nucleus was directly observed by the infrared, and the optical observations (Hanner et al. 1985, Sekanina 1988).

A sequential photographic observation of this comet was performed at the Dodaira Observatory. A significant time variation of the coma morphology was recognized. Watanabe (1987) analyzed the near-nucleus morphology using an image processing technique, and derived the rotational parameters of the nucleus. Sekanina (1988) also studied the nucleus rotation based on the persistent fan model with rather comprehensive data of the radar, radio, infrared, ultraviolet, and optical observations including the results of Watanabe (1987). However, some detailed morphological features of the coma were practically neglected in both studies. Hence, it is important to leave raw data of the photographic observations of this comet as a publication form. This paper presents a list of the plates, and reproductions of 18 representative plates together with isophotes to show the detailed variation of the coma morphology.

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2. Observations

A photographic observation was carried out by J. Watanabe, K. Saito, and K. Tomita with the 50-cm Schmidt telescope at the Dodaira Observatory, which belongs to the National Astronomical Observatory of Japan. The location is $\lambda=139°11'41''$ (9h16m47s), $\phi=+36°00'21''$, and 876 m above see level. A circular field of 3° radius is covered by a 4.7×4.7-inch plate. Focal ratio 2 of this telescope provides the plate scale of 206.3 arcsec/mm. 29 plates were obtained from May 7 through May 11. The list of these plates is shown in table 1.

This comet was also observed photographically with the 105 cm Schmidt telescope at the Kiso Observatory of the Institute of Astronomy, University of Tokyo. It is located at $\lambda=137°37'42''$ (9h10m30s), $\phi=+35°47'39''$, and 1130 m above see level. A 6°×6° field is covered by a 14×14-inch plate. Focal ratio 3.1 of this telescope provides the plate scale of 62.5 arcsec/mm. 7 nights could be used to obtain 14 photographic plates. Especially, B. Takase and S. Ichikawa observed this comet on May 12 when no plates was obtained at the Dodaira Observatory. One of their plates is also included in this paper to make up for the lack of the Dodaira observation.

3. Reduction

The representative plates of high quality were scanned with PDS1010MS microdensitometer at the National Astronomical Observatory. An aperture size of 50 μm×50 μm and a sample pitch of 40 μm were selected. The scanned region was 35′×35′ near the nucleus. Standard density-intensity conversion was carried out with the help of the characteristic curve defined by four step wedges exposed in the margin

Table 1. *List of plates*

Plate No.	Beginning of Exp. (1983. UT)	Exp. (sec.)	Position (1950. 0) α	δ	Geocentric Distance (A. U.)	Heliocentric Distance (A. U.	Elongation (degree)	Emulsion and Filter Txpe	
SB 3203	May 7 12:47:00	480	18h 25. 7m	+59° 58′	0. 105	1. 019	92. 4	103a-F	Y50
SB 3204	May 7 13:47:00	60	18h 25. 0m	+60° 6′	0. 104	1. 019	92. 4	103a-F	Y50
SB 3205	May 7 13:56:00	510	18h 24. 9m	+60° 8′	0. 104	1. 019	92. 4	103a-F	Y50
*SB 3207	May 7 15:05:00	360	18h 24. 0m	+60° 18′	0. 103	1. 019	92. 3	103a-F	Y50
SB 3209	May 7 15:22:00	180	18h 22. 1m	+60° 38′	0. 100	1. 018	92. 3	103a-O	—
SB 3210	May 7 15:31:00	180	18h 22. 0m	+60° 40′	0. 100	1. 018	92. 3	103a-F	—
SB 3212	May 7 16:47:45	165	18h 21. 8m	+60° 42′	0. 100	1. 018	92. 3	103a-O	—
*SB 3213	May 8 12:57:00	480	17h 59. 0m	+64° 17′	0. 081	1. 015	91. 7	103a-F	Y50
*SB 3214	May 8 14:04:00	240	17h 57. 2m	+64° 32′	0. 080	1. 015	91. 7	103a-O	—
SB 3215	May 8 14:14:00	300	17h 56. 9m	+64° 34′	0. 080	1. 015	91. 7	103a-F	—
*SB 3216	May 8 15:36:00	180	17h 54. 5m	+64° 53′	0. 079	1. 015	91. 6	103a-F	—
*SB 3217	May 8 15:43:00	180	17h 54. 3m	+64° 54′	0. 078	1. 015	91. 6	103a-O	—
*SB 3218	May 8 16:20:00	90	17h 53. 2m	+65° 3′	0. 078	1. 015	91. 6	103a-F	—
SB 3219	May 8 16:25:00	90	17h 53. 0m	+65° 4′	0. 078	1. 015	91. 6	103a-O	—
SB 3220	May 8 16:37:30	30	17h 52. 6m	+65° 7′	0. 078	1. 014	91. 6	103a-O	—
*SB 3221	May 9 11:39:00	480	16h 52. 4m	+70° 25′	0. 060	1. 012	90. 3	103a-F	Y50
*SB 3222	May 9 12:00:00	90	16h 50. 9m	+70° 30′	0. 059	1. 012	90. 3	103a-F	—
*SB 3223	May 9 13:03:00	90	16h 45. 3m	+70° 50′	0. 058	1. 012	90. 2	103a-O	—
*SB 3224	May 9 13:11:00	180	16h 44. 5m	+70° 52′	0. 058	1. 011	90. 2	103a-O	—
SB 3227	May 9 14:54:30	90	16h 34. 4m	+71° 24′	0. 057	1. 011	90. 0	103a-O	—
SB 3229	May 9 16:46:00	245	16h 22. 1m	+71° 57′	0. 055	1. 011	89. 8	103a-O	—
*SB 3230	May 9 16:56:00	240	16h 20. 9m	+72° 0′	0. 055	1. 011	89. 8	103a-O	—
*SB 3231	May 9 17:11:30	480	16h 18. 8m	+72° 5′	0. 055	1. 011	89. 8	103a-F	Y50
*SB 3235	May 10 15:19:00	360	11h 53. 4m	+70° 25′	0. 038	1. 008	86. 0	103a-F	SC50
*SB 3236	May 10 15:33:30	318	11h 50. 5m	+70° 14′	0. 038	1. 008	86. 0	103a-O	SC40
*SB 3238	May 11 13:35:00	240	9h 14. 7m	+38° 25′	0. 031	1. 005	80. 1	103a-O	SC40
*SB 3239	May 11 13:50:00	480	9h 13. 8m	+37° 54′	0. 031	1. 005	80. 0	103a-F	SC50
SB 3240	May 11 14:06:00	·360	9h 12. 9m	+37° 27′	0. 031	1. 005	80. 0	103a-O	SC40
SB 3241	May 11 14:41:00	480	9h 11. 0m	+36 22′	0. 031	1. 005	79. 8	103a-F	SC42
*K 4073	May 12 11:09:00	3306	8h 27. 9m	+ 4° 28′	0. 040	1. 003	77. 9	IIa-O	UGI

Notes: The plate number is the sepuential one designated by the Dodaira Observatory. Asterisk mark indicates the selected plate for reproduction in figure 1.

of each plate. The plates SB3224 and SB3239 were measured only for the density distribution because of no wedge data. Each plate datum was processed by so called "cleaning", which eliminates the images of stars and of plate defects (Watanabe 1987). Relative intensity unit is normalized by the maximum value of the nucleus on each plate. Figure 1 shows 18 representative photographs along with cleaned isophotes. The contour levels of the isophotes were listed in table 2.

4. Morphological features of the coma

The global structure of the morphology of this comet was a typical example of fan-shaped coma, which elongates normally to the sunward direction. This structure was observed in some short-period comets, and was believed to be an evidence of the anisotropic mass ejection from active regions on the cometary nucleus (Sekanina 1981). Watanabe (1987) found out the time variation of this feature quantitatively by an image processing technique of moment method. However, some of fine structures in the coma were practically neglected because the image processing in the analysis assumed implicitly that the fan-shaped coma consisted of a single component mass ejection. This situation is the same in other morphological studies. In this section, we emphasize these fine structures which was not considered so far.

On May 7, the coma elongated toward the east. On this night, Storrs et al. (1986) obtained CCD images of the inner coma of this comet using the University of Hawaii 2.2-m telescope at the Mauna Kea. Eastward elongation in their images of the 2.5′ region coincides with that of the 35′ region in SB3207.

On May 8, Storrs et al. (1986) remarked that direction of the elongation changed to the north in the inner region. However, the outer coma structure was rather circular as shown in SB3213–SB3219, and the center positions of these circular contours in the outer region was a little off the nucleus toward the north-east direction. This could indicate that the jet direction of a specific active region changed clockwise by the nucleus rotation (Watanabe 1987). Jockers et al. (1986) observed this comet photographically at May 8.9 UT. While the fan direction of the outer region was north or north-northwest,

Table 2. *Contour levels of the isophotos*

Plate No.	No. of Contours	Contour levels relative to the nucleus value (Intensity Units)							
SB 3207	4	0. 9800	0. 9200	0. 8600	0. 8000				
SB 3213	6	0. 9800	0. 9500	0. 9200	0. 8900	0. 8600	0. 8300		
SB 3214	7	0. 9700	0. 9267	0. 8833	0. 8400	0. 7967	0. 7533	0. 7100	
SB 3216	6	0. 9800	0. 9040	0. 8280	0. 7520	0. 6760	0. 6000		
SB 3217	6	0. 9800	0. 9220	0. 8640	0. 8060	0. 7480	0. 6900		
SB 3218	7	0. 9800	0. 9133	0. 8467	0. 7800	0. 7133	0. 6467	0. 5800	
SB 3219	6	0. 9800	0. 9200	0. 8600	0. 8000	0. 7400	0. 6800		
SB 3221	5	0. 9800	0. 9500	0. 9200	0. 8900	0. 8600			
SB 3222	7	0. 9800	0. 9167	0. 8533	0. 7900	0. 7267	0. 6633	0. 6000	
SB 3223	6	0. 9800	0. 9200	0. 8600	0. 8000	0. 7400	0. 6800		
SB 3224	6	0. 9800	0. 8740	0. 7680	0. 6620	0. 5560	0. 4500		
SB 3230	5	0. 9800	0. 9513	0. 9225	0. 8938	0. 8650			
SB 3231	5	0. 9800	0. 9475	0. 9150	0. 8825	0. 8500			
SB 3235	7	0. 9800	0. 9250	0. 8700	0. 8150	0. 7600	0. 7050	0. 6500	
SB 3236	6	0. 9800	0. 9400	0. 9000	0. 8600	0. 8200	0. 7800		
SB 3238	6	0. 9800	0. 9360	0. 8920	0. 8480	0. 8040	0. 7600		
SB 3239	6	0. 9600	0. 8480	0. 7360	0. 6240	0. 5120	0. 4000		
K 4073	8	0. 9800	0. 9144	0. 8426	0. 7743	0. 7057	0. 6371	0. 5686	0. 5000

Notes: The contour levels of SB3224 and SB3239 is the density unit relative to the nucleus value.

the jet in the inner region pointed to the northeast. Because this observation was 5 hrs after that of the last plate SB3219 on May 8, the strong northward activity observed at May 8.5–8.7 seems to have disappeared. The northeast component observed by Jockers et al. (1986) seems to have begun as a new activity of another region. In fact, this new eastward activity was recognized as a weak second component on the near-nucleus CCD images taken at May 8.6 (Storrs et al. 1986).

On May 9, the fan direction of the inner coma was almost similar to that on May 8. However, the outer coma was more elongated toward the northeast than that of May 8. This may be a remnant of the northeast activity observed by Jockers et al. (1986). It is worthwhile to note that the westward component of the fan continued to develop during the observation, which can be recognized in SB3221–SB3231. Hence, the eastward secondary component of the activity at May 8.6 grew to the northeast component at May 8.9, and it was also observed as a northward jet component on May 9.5–9.8. Moreover, Oliversen et al. (1985) reported the northwest elongated structure in the inner region of $\sim 10'$ at May 10.25. This clockwise rotational sense is consistent with that derived by Watanabe (1987).

Two plates SB3235–SB3236 were taken at May 10.65, which was 10 hrs after the observation of Oliversen et al. (1985). The strongly elongated, westward jet structure was recognized in these plates. Taking account of the rotational sense and of the variation of the morphology, we may consider this westward component as the same activity as observed from May 8.6 through May 10.25.

On May 11, the morphology of the coma was almost similar to that in previous night. The elongated jet structure pointed to the west. Because of the lack of data, we cannot determine whether this activity was the same one on May 9–10 or not. On the other hand, the outer coma elongated to the west-southwest. Sekanina (1988) derived three components in the activity from the morphological analysis, and suggested that activities of the region "A" and "C" in his designation would be observed at this time in the west and in the southwest, respectively. The outer coma elongation in the west-southwest may be due to the region "C". However, the near-nucleus images taken by Storrs et al. (1986) shows a complex structure which suggests the existence of northward component. This may be an evidence of the other active region which was not found out either by Sekanina (1988), or by Watanabe (1987).

The elongation of the outer coma was the west-northwest direction on May 12.5. The inner coma elongated to the west as same as that on May 11. On the other hand, a near-nucleus image of Storrs et al. (1986) at May 12.3 shows the west-southwest component of the activity. These facts may indicate the counterclockwise sense of the rotation, which is consistent with that derived by Watanabe (1987) and by Sekanina (1988). It is interesting to note that the near-nucleus CCD images at May 13.0 also shows a westward elongated structure (Festou et al. 1987). Although this data was not analyzed by Sekanina (1988), this westward source seems to be the active region "B" in his study. It should be noted that the geometrical relation between the comet and the Earth changed drastically by the close approach on May 11.5. Hence the morphological change was due to the time variation of not only the nucleus activity, but also the geometrical condition. We must take care of this situation in considering the time variation of the morphology.

Some phenomena of the brightness increase of this comet were also reported. Feldman et al. (1984) observed the UV outburst peaked at May 11.8 by the

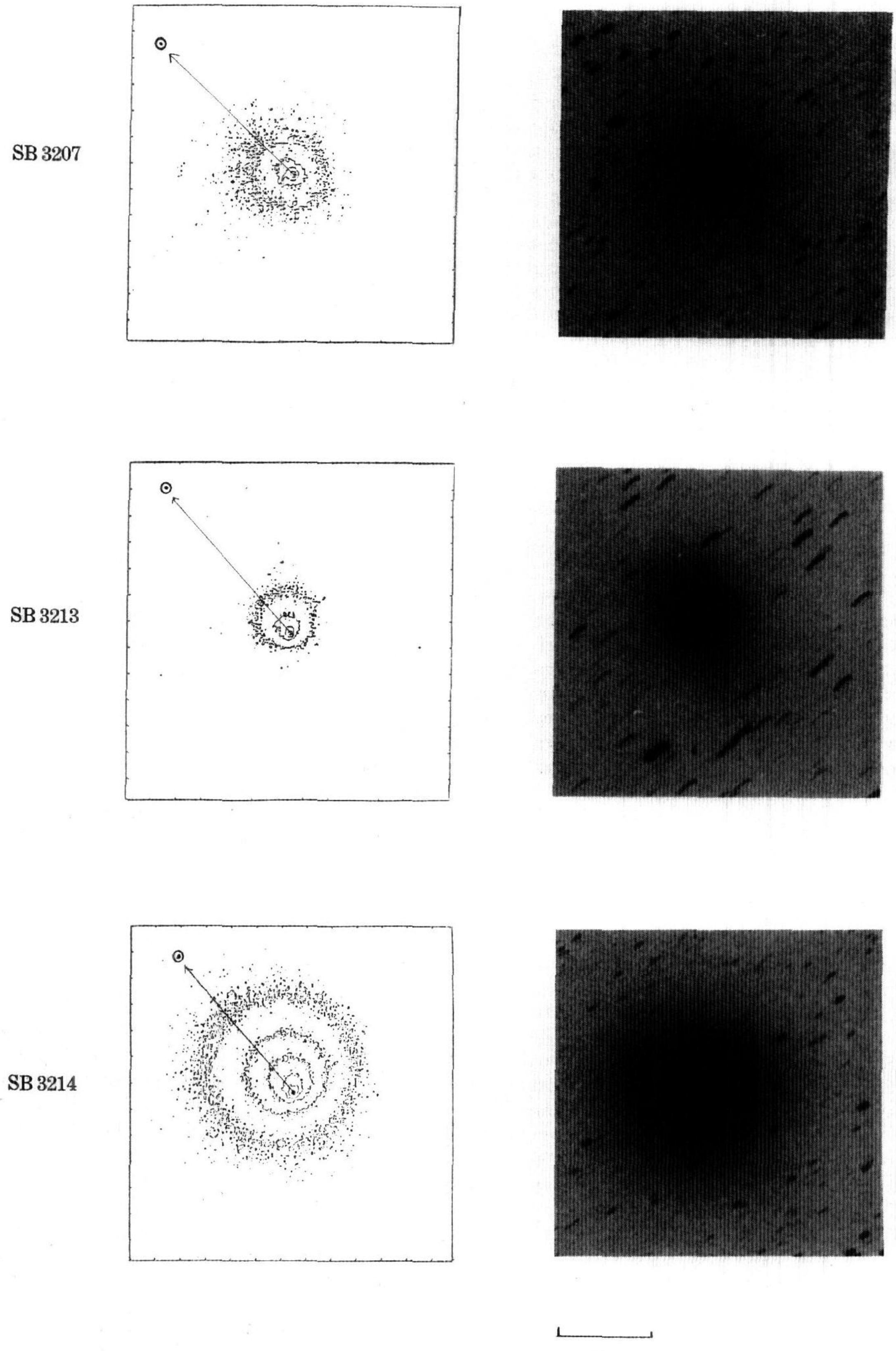
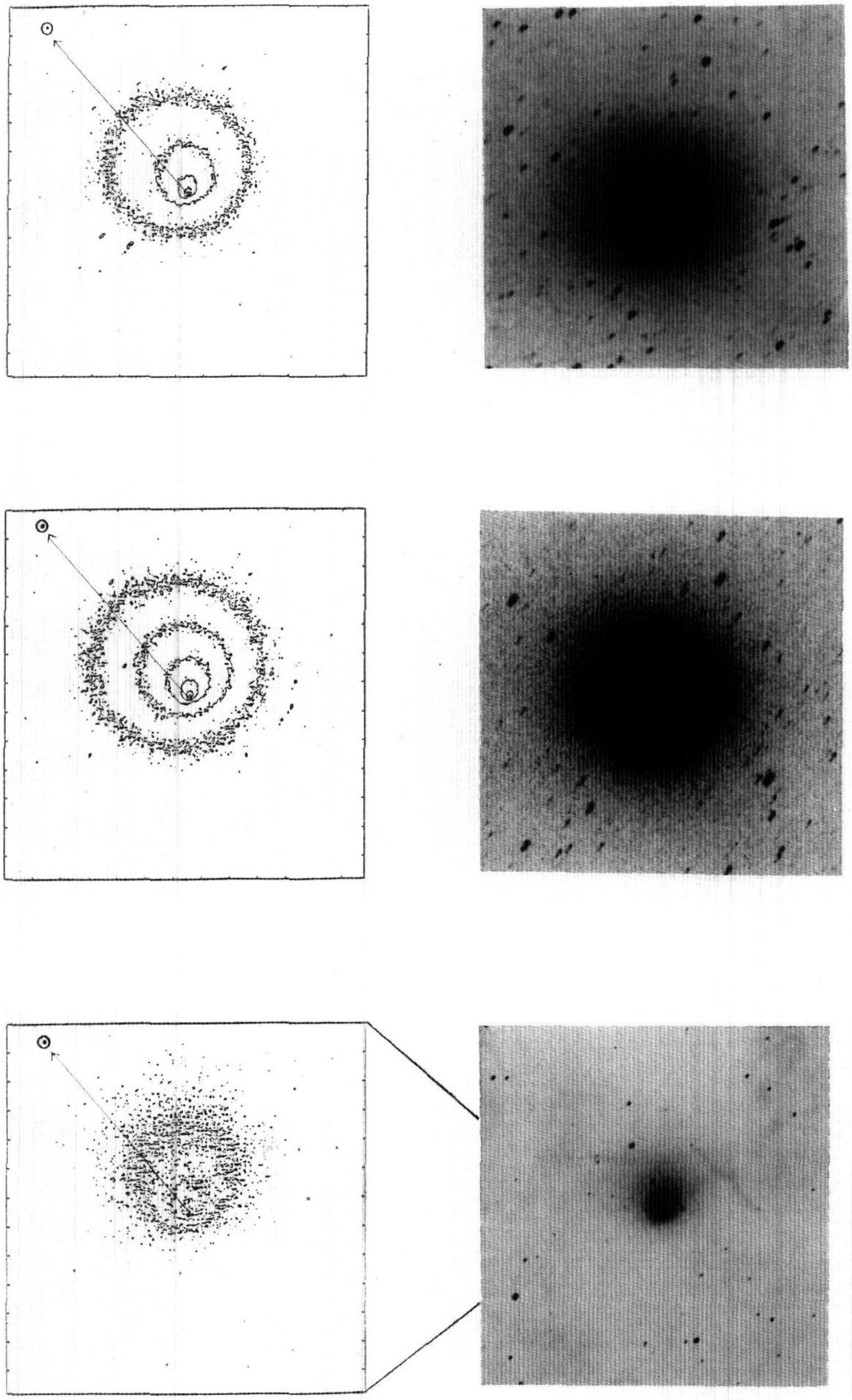


Fig. 1. *A photographic atlas of Comet IRAS-Araki-Alcock 1983 VII. North is top and east is left. The scale bar in the figure is 10 arcmin in length. Scale of the isophotos is the same as the photographs except SB3218 and K4073. Coutour levels are arbitrary determined in order to visualize the near-nucleus morphology. These selected levels are listed in table 2.*



SB3216

SB3217

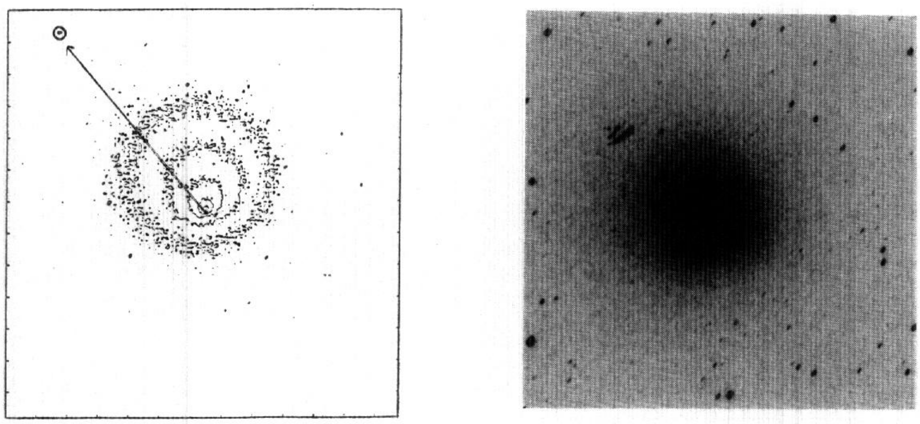
SB3218

2×

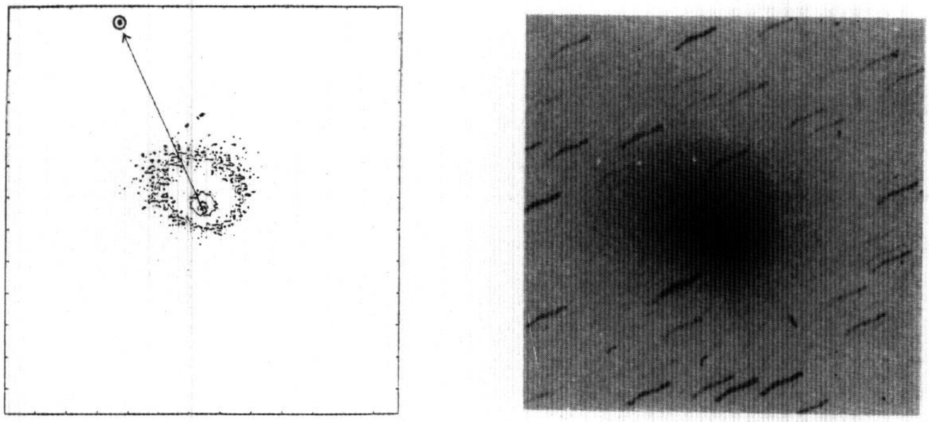
10′

Fig. 1-2.

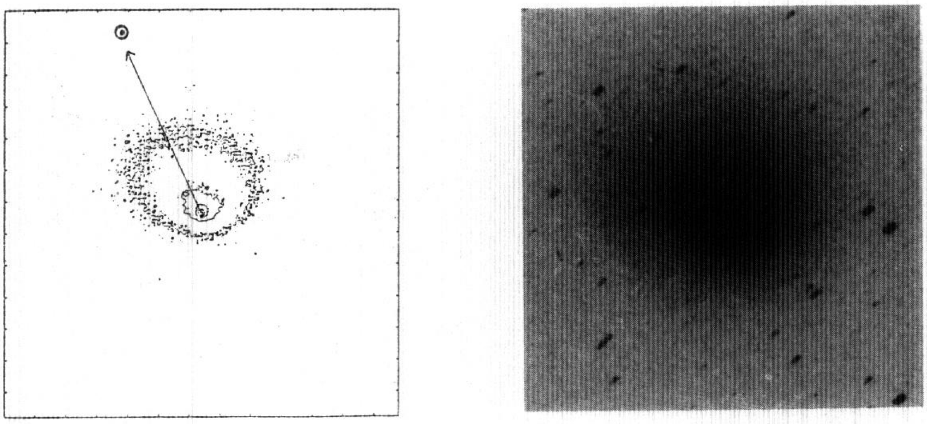
SB3219



SB3221

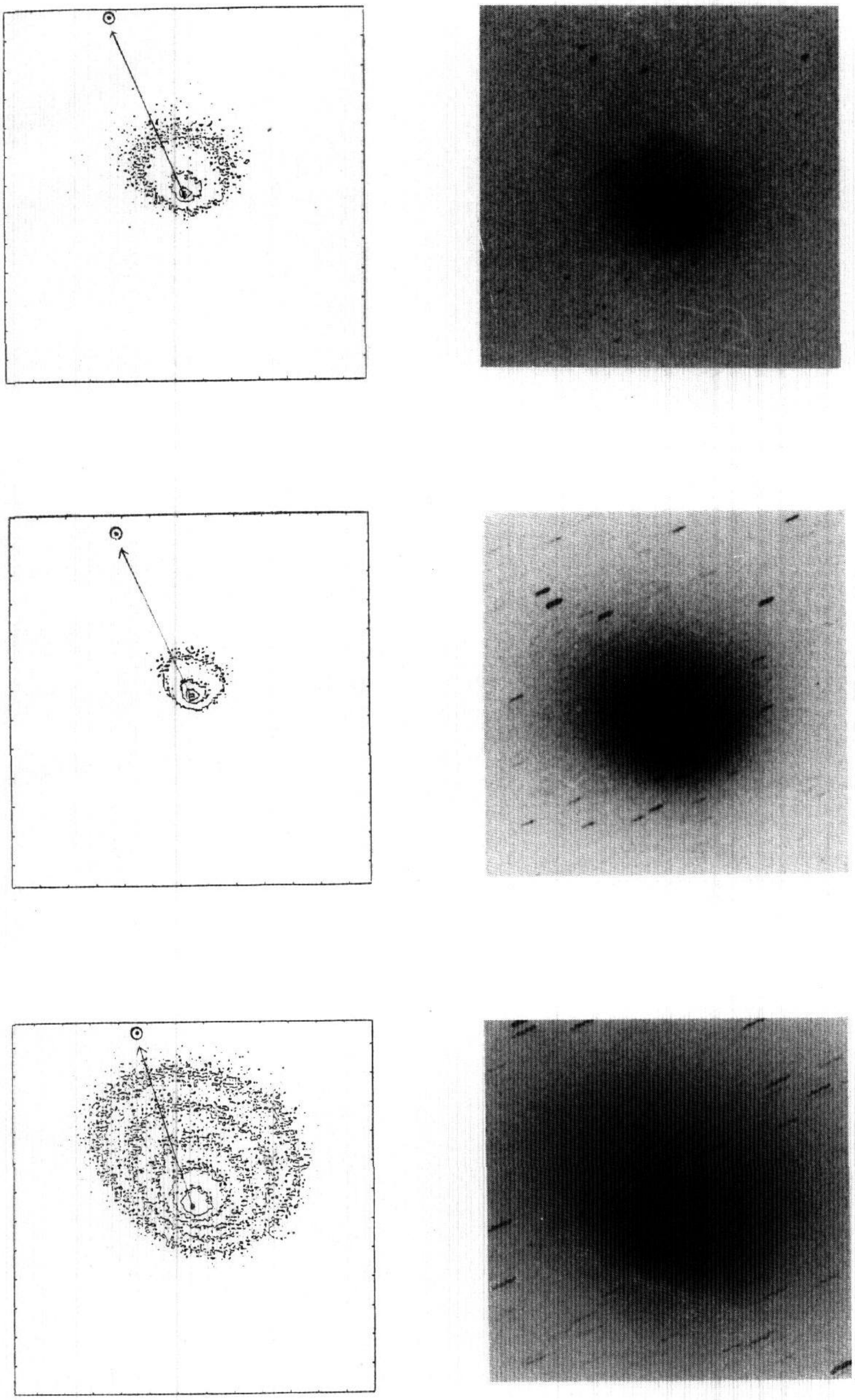


SB3222



10′

Fig. 1-3.



SB3223

SB3224

SB3230

10′

Fig. 1-4.

SB3231

SB3235

SB3236

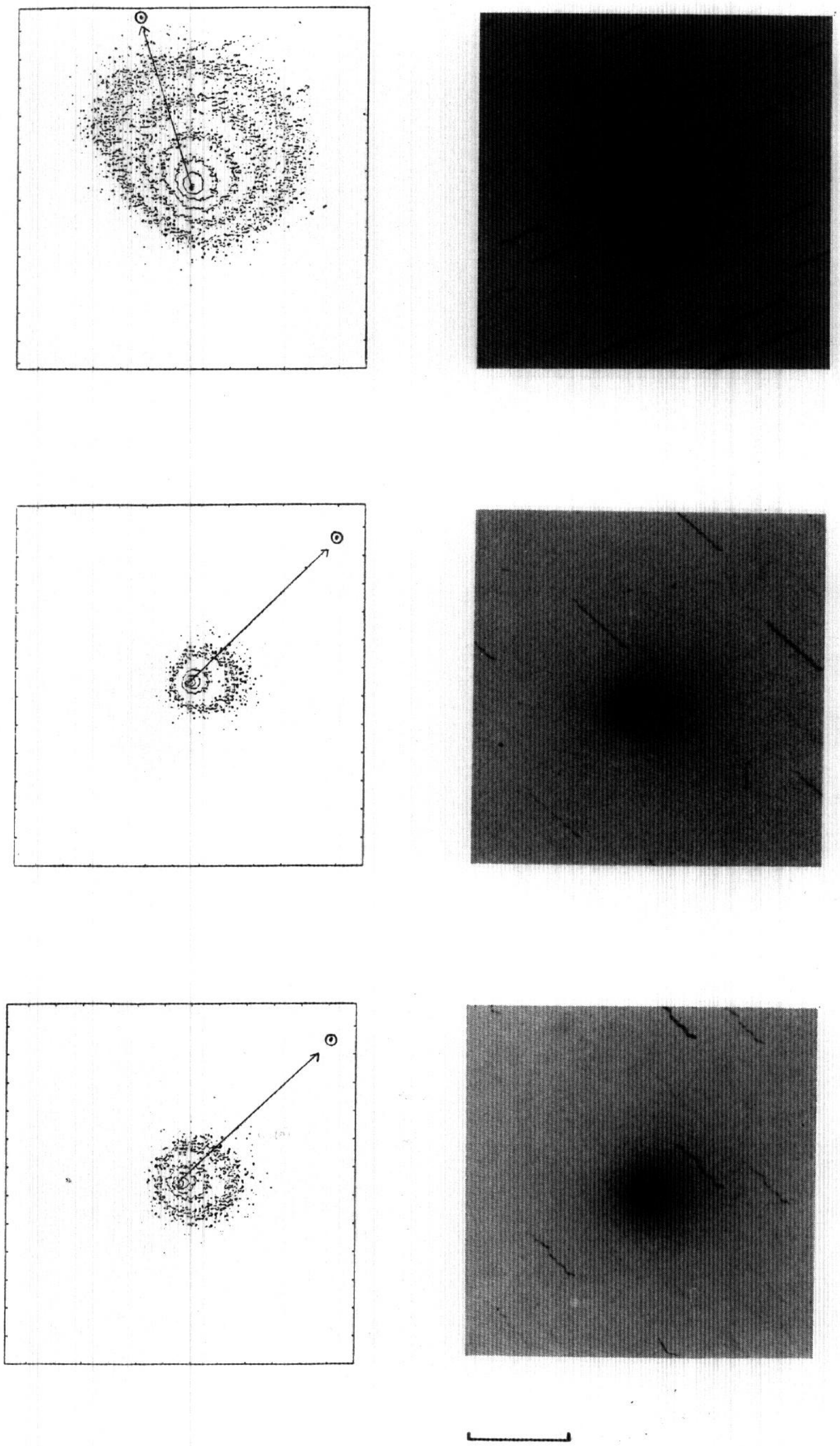


Fig. 1-5.

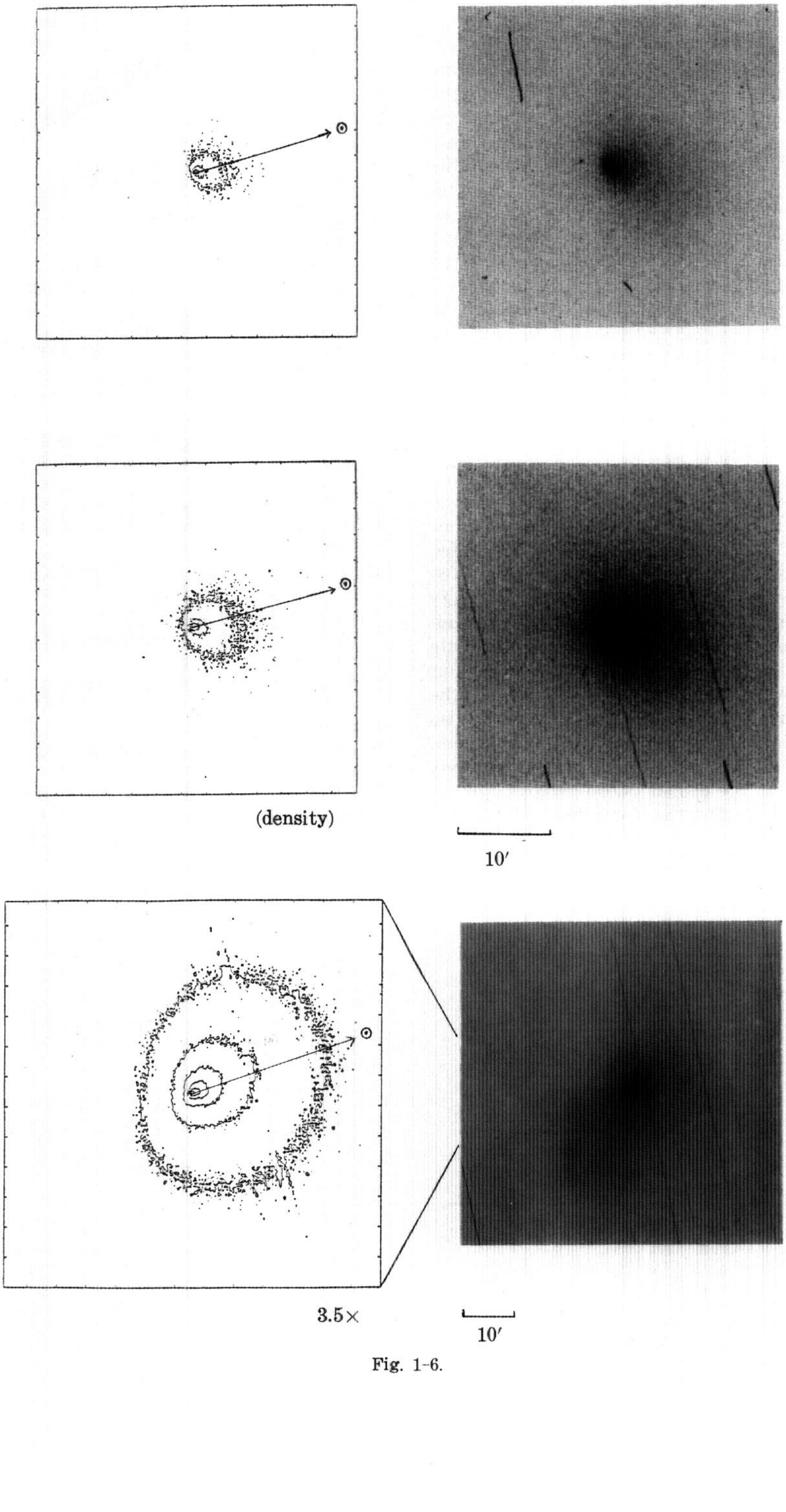


Fig. 1-6.

IUE Fine Error Sensor. Feierberg et al. (1984) also reported the initial stage of the outburst at May 11.2 by IR observation. These observations may indicate that the observed westward elongated structure in the plate SB3238–SB3239 on May 11.6 was the increasing stage of the outburst activity. On the other hand, one magnitude rise on May 12 was reported from visual observations by Morris and Green (1983). Lutz and Wagner (1986) also found out the short time variation of the spectrum during 20 min. on May 10. These two phenomena may have been caused by the solar wind interaction (Morris and Green 1983, Lutz and Wagner 1986). Because of the lack of sequential photometric observation except two nights photometry by A'Hearn et al. (1984), it is difficult to reveal the global behavior of the activity together with these outburst phenomena.

5. Tail structure

The tail-less appearance of this comet is probably due to the law production rate of the ion material. However, faint ion tail was observed only on May 9. On the reproduction of the plate SB3221, a faint, narrow ion tail structure is recognized. As stated above section, the active region seems to have ejected material continuously at least from May 8.6 through 10.65, it may be difficult to attribute this ion tail formation to drastic increase of the production rate by an outburst. Niedner et al. (1989) pointed out the relation between this short lived tail and the X-class solar flare. Lutz and Wagner (1986) also found out the short time variation of the spectrum, and suggested the collision of the compression wave in the solar wind to the comet. More detailed studies will be needed to clarify the formation of the ion tail in this comet.

The author is grateful to Dr. K. Hurukawa for his calculation of the orbit and position of this comet. He acknowledges his indebtness to Messrs. K. Saito and K. Tomita for continuous discussion and encouragement. He also wishes to express his hearty thanks to Drs. B. Takase and S. Ichikawa for permission to use their valuable plate.

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