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The Spectrum of Comet Ikeya-Seki (1965f)

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Abstract

Spectroscopic observations of Comet Ikeya-Seki (1965f) with slit and slitless instruments are described. Sodium emission in the coma is seen from October 9 to November 1. A sodium tail extending upto 2° from the nucleus has been seen.

Spectroscopic observations of Comet Ikeya-Seki were commenced on October 9, 1965 and carried through beyond perihelion until November 4, when the Comet was 0.63 A.U. from the Sun. The spectra were obtained both with slit and slitless instruments. The cassegrain grating spectrograph on the 50 cm. reflector was used in the first order with a dispersion of 250 A/mm. Two slit spectra were obtained on October 30.985 ($r=0.497$ A.U.) and November 3.975 ($r=0.626$ A.U.), using Eastman Kodak 103a-F emulsion with exposure times of 30 and 45 minutes respectively. The nucleus was guided on the slit. On other days, particularly prior to perihelion passage and on a few days after perihelion passage, until October 31, the same spectrograph was used in the slitless mode. A field lens was used in place of the slit and the whole spectrograph functioned essentially as a Meinel camera with a grating for dispersing the light. The scale in the focal plane of the 50 cm. telescope is 10′/mm. The ratio of collimator to camera focal lengths is 7.5. The spectra were obtained in the first order covering the range 4700A to 6800A and in the second order from 3800A to 4800A. Exposures were of the order of 1 to 2 minutes for both the blue and red regions of the spectrum on Eastman 103a- F emulsion, during which period the comet was guided with the aid of the finder telescope.

Two other slitless instruments functioned simultaneously on the 50 cm. mounting for obtaining prismatic spectra of the cometary head and the cometary tail. Both used 60° glass prisms and the cameras were of focal lengths 5 cm. and 28 cm. with aperture ratios of f/2 and f/5.6. The emulsion used was Kodak Linagraph Shellburst film, and while a certain degree of reciprocity failure exists with this emulsion, its primary advantage was the extensive wavelength coverage possible combined with speed, since the emulsion is sensitive to about 7100A. The dispersions at $H\gamma$ are 360A/mm for the 5 cm. camera and 65A/mm for the 28 cm. camera. Exposure times on nights free of moonlight rarely exceeded 20 minutes. The longer focal length prismatic camera had a field of about 4.5° by 6.5° and showed details of the tail spectrum out to 3° from the nucleus. The shorter focal length prismatic camera could follow the tail spectrum to 12°.

The close approach of Comet Ikeya-Seki to the Sun coincided with the peak of the spell of very bad weather due to the North-east monsoon that we have at Kodaikanal. This prevented us particularly from exploiting the solar spectrographic instrumentation available at Kodaikanal, especially on October 21 when the comet was closest to the Sun. Also, until November 1, moonlight prevented long exposures with the slitless instruments. In Table I, we give details of the spectra obtained at Kodaikanal of this comet.

TABLE I

Instrument	Date	Time U.T. h.	m.	Heliocentric distance A.U.	Exposure	Emulsion	Wavelength Region	Remarks
50cm. Cassegrain slit spectrograph.	October, 30	23	40	0.497	30 min.	103a-F	3800—6700A	Well-exposed spectrum. D lines strongest feature.
	November, 3	23	24	0.626	50 min.	103a-F	3800—6700A	Swan bands and CN (0,0) well-exposed, NH bands in visual region seen.
50cm. Cassegrain slitless spectrograph.	October, 11	23	36	0.509	3 min.	103a-F	3800—4800A (second order).	CN moderate strength; C_2 weak. Dispersion 125A/mm.
		23	45		10 min.	103a-F	3800—4800A	Well-exposed.
		23	56		3 min.	103a-F	3800—4800A	Sky fog present.
	October, 12	23	38	0.474	2 min.	103a-F	3800—4800A	Well-exposed.
		23	42		4 min.	103a-F	3800—4800A	Well-exposed. C_2 stronger than on October 11.
		23	51		6 min.	103a-F	3800—6700A (first order).	Over-exposed.
		23	58		3 min.	103a-F	3800—6700A	Over exposed for photometry — Na emission strong.
	October, 29	23	40	0.426	1 min.	103a-F	3800—4800A (Second order).	Under exposed.
		23	37		2 min.	103a-F	3800—4800A	Well-exposed.
		23	33		25 secs.	103a-F	3800—6700A (first order).	Very well-exposed.
		23	32		60 secs.	103a-F	3800—6700A	Over-exposed for photometry.
		23	34		20 secs.	103a-F	3800—6700A	Well-exposed for photometry. Intense Na emission.
		23	55		30 secs.	103a-F	3800—6700A	Poor.
		23	56		1 min.	103a-F	3800—6700A	Well-exposed.
		23	50		2 min.	103a-F	3800—6700A	Over-exposed.
28cm. Prismatic camera.	October, 8	23	46		32 min.	Kodak Linagraph Shellburst.	3850—7100A	Over-exposed.
	October, 16	00	00		3 min.	Do.	3850—7100A	Fogged by twilight.
	October, 28	23	37		19 min.	Do.	3850—7100A	Well-exposed.
		23	50		4 min.	Do.	3850—7100A	Good.
	October, 29	23	40		10 min.	Kodak Linagraph Shellburst	3850—7100A	Well-exposed.
	October, 30	23	28		27 min.	Do.	3850—7100A	Very well-exposed.
		23	42		2 min.	Do.	3850—7100A	Good.
	October, 31	23	13		15 min.	103a-F	3800—6700A	Through clouds —slightly under-exposed.

TABLE I—*Contd.*

Instrument	Date	Time U.T. h.	m.	Helio-centric distance A.U.	Exposure	Emulsion	Wavelength Region	Remarks
	November, 2	23	12		16 min.	Kodak Li nagraph Shellburst.	3850—7100A	Good.
	November, 3	23	18		45 min.	Do.	3850—7100A	Very good.
	November, 4	23	29		18 min.	Baked IIa-o	3800—4800A	Good.
) cm. Prismatic Camera	October, 28	23	37		19 min.	Kodak Linagraph Shellburst.	3850—7100A	Slightly fogged.
	November, 3	23	07		25 min.	Do.	3850—7100A	Very good.
		23	30		20 min.	Do.	3850—7100A	Very good.

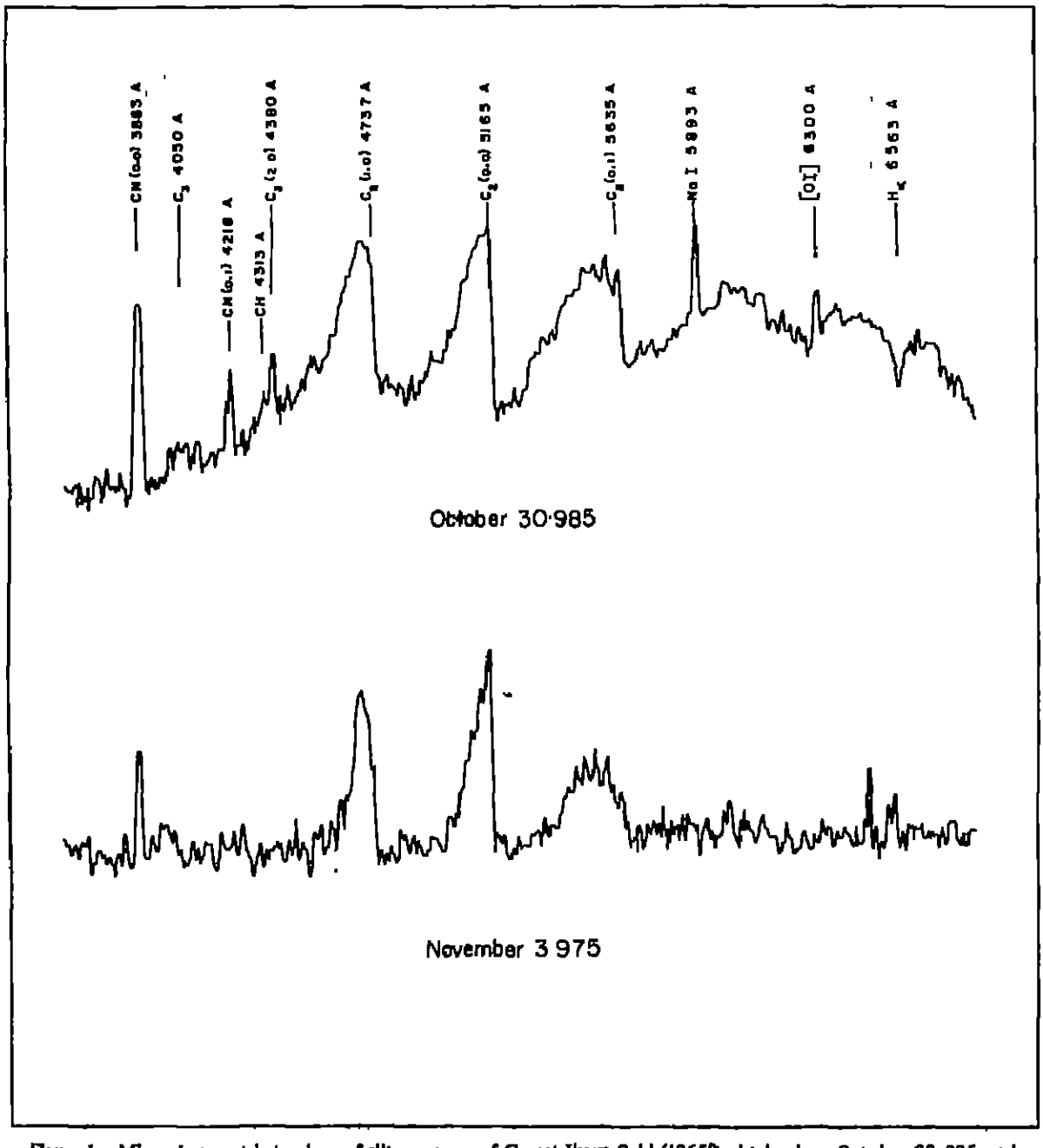

Figure 1. Microphotometric tracings of slit spectrum of Comet Ikeya-Seki (1965f) obtained on October 30·985 and November 3·975.

Figure 1 shows microphotometer tracings of the slit spectrograms obtained on October 30.985 and November 3.975. The swan bands of C_2, the CN bands, and the D line of sodium are the dominant features of the spectrum. The brightest lines in the spectrum on that day were the D lines of sodium. The cometary head displayed a fairly strong continuous spectrum. Particularly noteworthy is the very strong Hα absorption line that can be seen in the spectrum of the nucleus. Also easily seen is the Hβ absorption line. The other features in the spectrum are the bands of NH_2 particularly near 5976A, and an emission feature at 6299A which we identify as the forbidden oxygen line at 6300A.

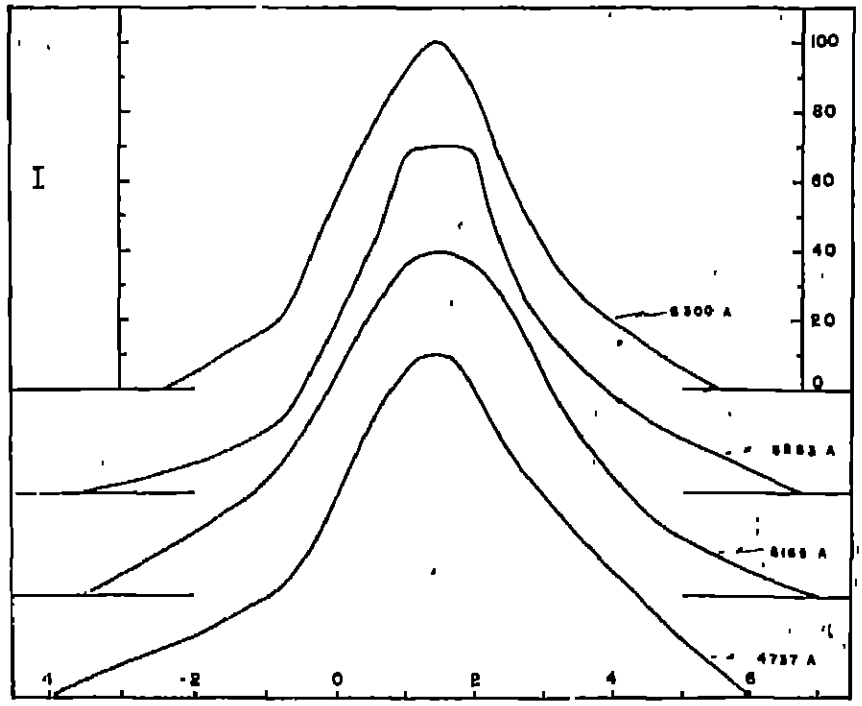

Figure 2 Intensity distributions perpendicular to the dispersion in the monochromatic images of the coma. These scans are of the slit-spectrum of October 30.985.

The intensity distributions across the coma in the light of the C_2 bands and Na-emission can be seen in figure 2 where we also include the intensity distributions of 6300A of OI. An easily noticeable feature is the steep intensity gradient in the direction of the sun. This aspect is most striking in the case of Na-emission, possibly by virtue of the high 'f' value of the D lines.

The spectra obtained with the prismatic cameras as well as with the slitless cassegrain spectrograph have a fair coverage on either side of the time of perihelion passage. The D line in emission was seen to be weak on the first prismatic spectrum obtained on October 8.99. Subsequently on all spectra obtained until November 1, the Na-emission in the cometary head was easily detectable.

Soon after perihelion passage we had a spell of bad weather, that prevented us from obtaining spectra for over a week. Our first slitless spectrum obtained after perihelion was on October 29, and this showed very bright Na-emission in the coma. The 28 cm. prismatic camera spectra show the Na-emission extending into the tail to about 2°. This feature is seen on our prismatic spectra until November 1. In figure 3, we give a succession of scans at different distances from the cometary head to show the intensity of Na-emission in the tail. The sodium tail is relatively narrow, with little spread. This tail seems to possess a slight inclination to the dust tail of the comet. We have tried to reconstruct the position of the sodium tail against the sky background on a picture obtained at Kodaikanal with a Schmidt camera at the same time. While the

procedure we have adopted is of low accuracy in defining position, it indicates, that the sodium tail was approximately along the direction of the radius vector from the

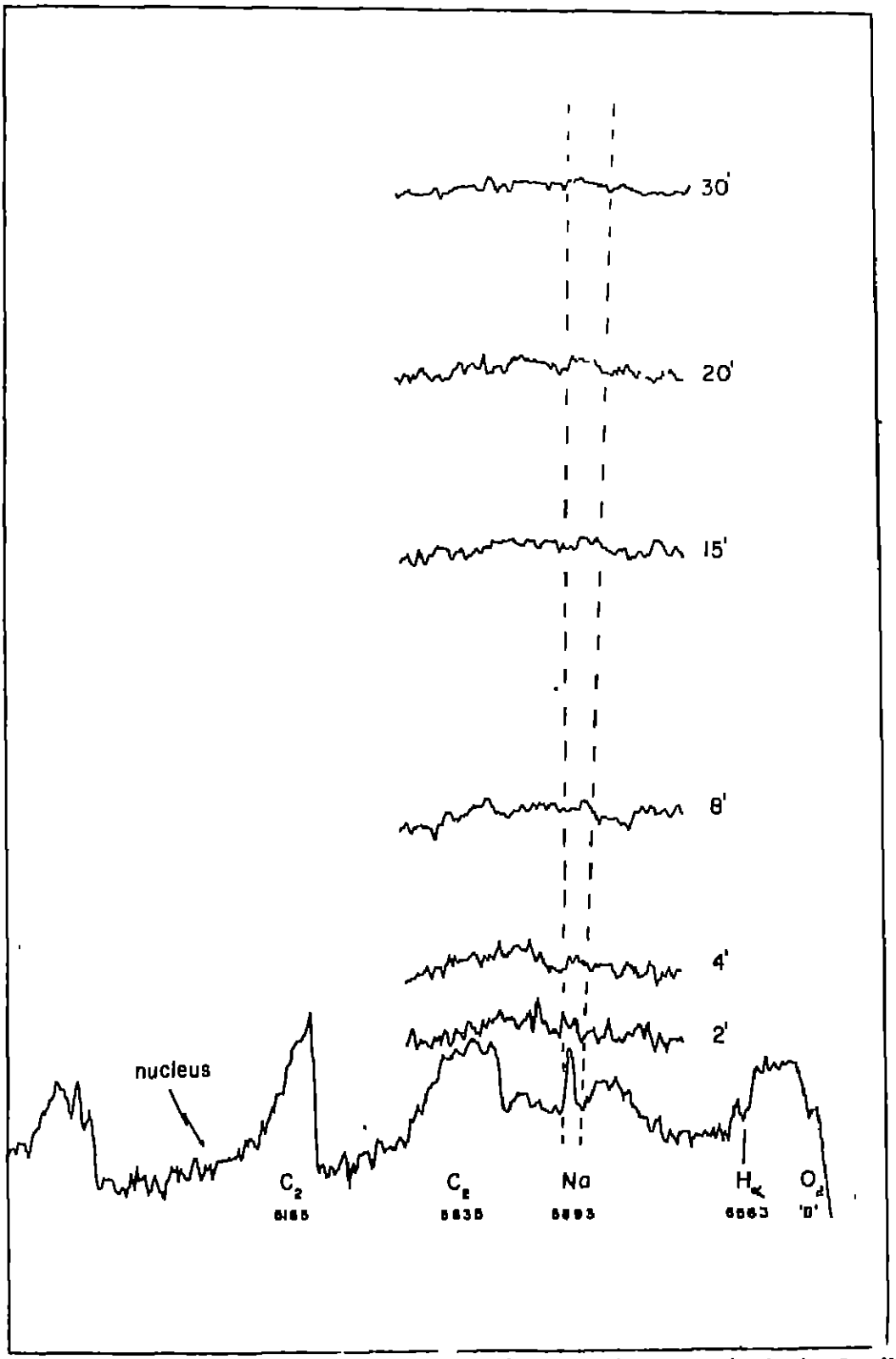

Figure 3, Successive scans at distances 2', 4', 8', 15', 20' and 30', from the cometary head. The Na-tail is seen easily. The dotted lines indicate the boundaries of the spread of the tail. The scans are of the prismatic spectrum obtained with the 28cm. prismatic camera on October 30.985.

Sun. The tail spectra obtained on both prismatic cameras show a predominantly continuous spectrum which we interpret as due to scattering by the abundant dust in the tail that was present after the comet's encounter with the Sun. The tail bands of CO^+ can be seen very weakly on the 28cm. prismatic spectrum obtained on October 30.985. Hence, we conclude that while the tail spectrum has been dominantly a continuous one, it nevertheless showed the tail bands of CO^+ weakly and showed up well a sodium tail extending a little beyond 2°.

We last saw the Na-emission in the coma on October 31.967. This is on the basis of a prismatic spectrum. On November 2.967 we could detect no Na-emission in the coma on a normal 16 minute exposure. On November 3.971, well-exposed pictures have been obtained with both prismatic cameras and these fail to show any trace of Na-emission. This was also confirmed on a slit spectrogram obtained of the comet, which, though a little underexposed, shows up all the strong emission bands in the comet and should have shown the D lines in emission, if they were of weak to moderate intensity. We thus consider, that, the Na-emission ceased to exist sometime from November 3 onwards, when the comet was at a heliocentric distance of 0.593 A. U. This conclusion seems surprising in view of the fact that Na-emission is generally supposed to occur in comets, when their heliocentric distances are less than 0.8 A.U. However, our observations of November 3 and 4, from different spectra obtained with two different instruments, show clearly beyond doubt, that the Na-emission ceased to exist on these dates.

The cassegrain slitless spectra have been obtained with a telescope scale of 10"/mm. We have well-exposed spectra, both before and after perihelion passage and these will be used for the derivation of isophotes of the C_2 (1,0) band as well as the CN (0,0) band. The results will be published later. Since the effective scale in the spectrograph focal plane is 75"/mm. the dispersion of 250A/mm is low enough to show the CN (0,0) band as a single blob of emission. In contrast to this situation we have the 28 cm. prismatic spectra show up the coma, resolved in the P and R branches by virtue of the much greater dispersion used in combination with the small telescopic scale.

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