SPECTROSCOPIC OBSERVATIONS OF COMET KOHOUTEK (1973f) II

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Systematic spectroscopic observations of comet Kohoutek (1973f) were scheduled at the Asiago Astrophysical Observatory, starting from the end of October. The nebular spectrograph for the newtonian focus of the 122 cm reflector was selected as main instrument for this research. This spectrograph, described by Bertola (1970), is followed by a WL-30677 image tube and it is particularly designed for extended objects of low surface brightness. Two gratings were used giving a dispersion in the first order of 125 Å mm^{-1} and 240 Å mm^{-1} respectively. The scale normal to the dispersion is 127 arcsec mm^{-1} and the full length of the slit is 8 arcmin.

Weather conditions, particularly bad after the 25th of January, shortened the observational program, and the 40 available spectra cover six nights before perihelion and five nights after perihelion. The material is listed in Table I.

As already published (Herbig, 1973, Benvenuti and Wurm, 1974) the first spectra of the coma of comet Kohoutek were characterised by some fairly strong, asymmetric, unidentified emissions in the red and the near infrared spectral regions. From these very preliminary indications Herzberg and Lew (1974) proposed a tentative identification of the H_2O^+ ion. As soon as the comet approached the perihelion and further spectra became available, other H_2O^+ emissions appeared (Benvenuti, 1974, Wehinger and Wyckoff, 1974), and the tentative identification was confirmed (Wehinger et al., 1974).

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Table 1
Log of Observations

Date	r	Δ	Spectrum No	U.T.		Exposure	Dispersion	
Oct 30	1.55	2.15	2127	4^h	19^m	17^m	240 Å mm^{-1}	
			2128	4	33	6	240	
Oct 31	1.53	2.12	2137	3	50	10	240	
			2138	4	14	10	240	
			2139	4	29	15	240	
Nov 2	1.49	2.06	2150	4	00	20	125	
Nov 21	1.10	1.58	2166	4	12	10	125	
			2167	4	25	3	125	
			2168	4	38	10	125	
			2169	4	49	15	125	
Nov 23	1.06	1.53	2171	4	29	20	125	
			2172	4	56	20	125	
Dec 4	0.80	1.30	2195	4	55	5	240	
			2196	5	02	1	240	
			2197	5	15	5	240	
			2198	5	25	10	240	
Dec 6	0.75	1.27	2199	5	07	5	240	
			2200	5	22	5	240	+
Jan 17	0 70	0.82	2227	17	18	3	240	
			2228	17	25	10	240	
			2229	17	37	5	240	
			2230	17	46	1	240	
			2231	18	10	15	240	+
			2232	18	28	15	240	+
Jan 18	0.73	0.83	2235	17	32	10	125	
			2236	17	41	4	125	
			2237	17	52	10	125	
			2238	18	18	5	240	+
			2239	18	35	20	240	+
			2240	18	54	15	240	+
Jan 23	0.85	0.87	2266	17	27	4	125	
			2267	17	36	10	125	
			2268	17	47	3	125	
			2269	18	02	10	125	
			2270	18	18	15	125	
			2271	18	50	30	125	+
Jan 25	0.90	0.90	2277	17	54	1	240	
			2278	17	57	10	240	
			2279	18	05	10	240	
			2280	18	15	1	240	
			2281	18	31	15	240	+

(+) Tail Spectrum

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H_2O^+ emissions were measured in two high quality Asiago spectra. The resulting wavelengths, in good agreement with those published by Wehinger et al. (1974), are listed in table II, together with laboratory data. In these spectra some features remain still unidentified, even if, as for their spatial behaviour, i.e. the asymmetricity respect to the continuum, they look like ion emissions. As the H_2O^+ bands identified so far belong to the v' progression (0,v',0) - (0,0,0), it is likely that the unidentified lines come from other progressions with higher vibrational levels in the lower state. These progressions are present in the laboratory spectra but not yet completely analysed.

H_2O^+ emissions are extremely asymmetric respect to the nucleus. This is shown in Fig.2, where two microphotometric tracings of the spectrum No 2235 are reported: in case a the slit was put on the tail side, in case b on the opposite (Sun) side, symmetrically respect to the continuum. The distance between the two slit positions was 2×10^5 Km. Moreover Fig. 3 shows the profiles, normal to the dispersion, of the two more prominent lines of H_2O^+ and of the adjacent continuum (the profile of the 6122 Å NH_2 line is also reported for comparison). From these tracings an upper limit of 2.5×10^4 Km can be derived for the extension of the H_2O^+ ions towards the Sun. For several spectra the slit of the spectrograph was set normal to the radius vector in order to derive the radial distribution of H_2O^+ around the nucleus, but in that case no traces of ions emission was found over the continuum.

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Table II

Cometary and Laboratory Lines of H_2O^+

Sp No 2171	Sp No 2235	Laboratory (Å)	Assignement	
-	5521.0	5521.2	10-0, Π	$^pP_{2,N-2}(2)$
-	5798.3	5799 7	9-0, Σ	$^pQ_{1,N}(3)$
-	5915.7	5915.3	9-0, Δ	$^pP_{3,N-2}(3)$
6148.3	6146.9	6147.1	8-0, Π	$^rR_{0,N}(0)$
6158.4	6158.1	6158.7	8-0, Π	$^rQ_{0,N}(2)$
6187.5	6187.3	6187.2	8-0, Π	$^pQ_{2,N-1}(3)$
6199 7	6199.6	6199.4	8-0, Π	$^pP_{2,N-2}(2)$
-	6210.6	6210.5	8-0, Π	$^pP_{2,N-2}(3)$
-	6222.9	6222.4	8-0, Π	$^pP_{2,N-2}(4)$
-	6542.6	6542.8	7-0, Σ	$^pQ_{1,N}(1)$
-	6561.8	6562 7	7-0, Σ	$^pP_{1,N-1}(1)$
6576.2	6576.9	6575.0	7-0, Δ	$^rR_{1,N}(1)$
-	6594.2	6594.3	7-0, Δ	$^rQ_{1,N}(4)$
6684.9	6686.7	6686.0	7-0, Δ	$^pP_{3,N-2}(3)$
6969.9	-	6971.9	6-0, Π	$^rR_{0,N}(0)$
6984.4	-	6986.5	6-0, Π	$^rQ_{0,N}(2)$
7039.2	-	7039.3	6-0, Π	$^pP_{2,N-2}(2)$
7052 7	-	7054.1	6-0, Π	$^pP_{2,N-1}(3)$
7069.8	-	7069.9	6-0, Π	$^pP_{2,N-2}(4)$

Laboratory wavelengths are averages of the spin doublets

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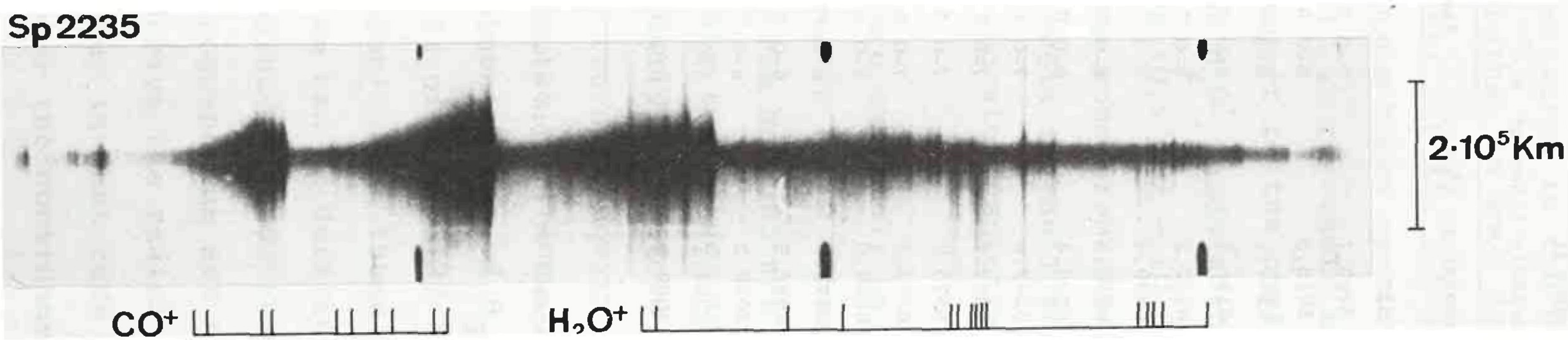

Fig. 1 - Comet Kohoutek. Spectrum No 2235, Jan 18.73 U.T.
The slit was put along the radius vector.

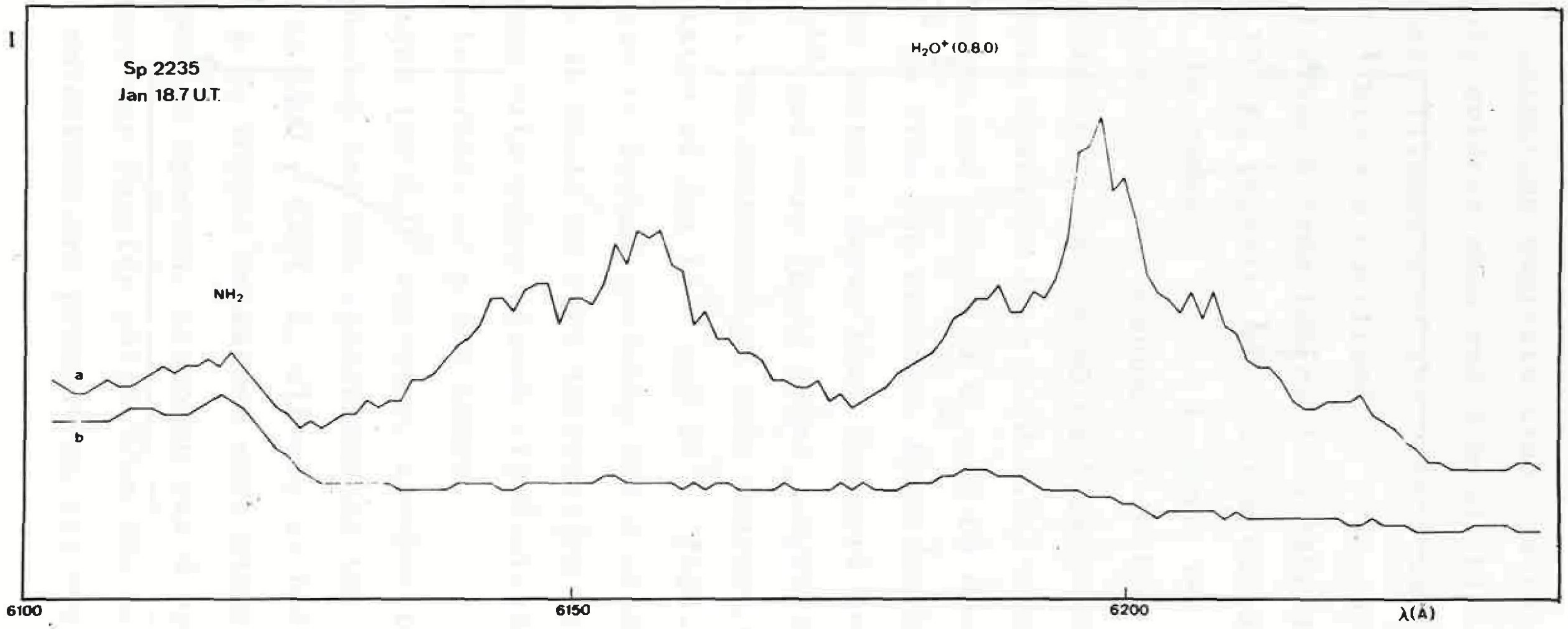

Fig. 2 - Microphotometric tracings of Spectrum No 2235 (see Fig. 1). The microphotometric slit in case a was towards the tail, in case b towards the Sun.

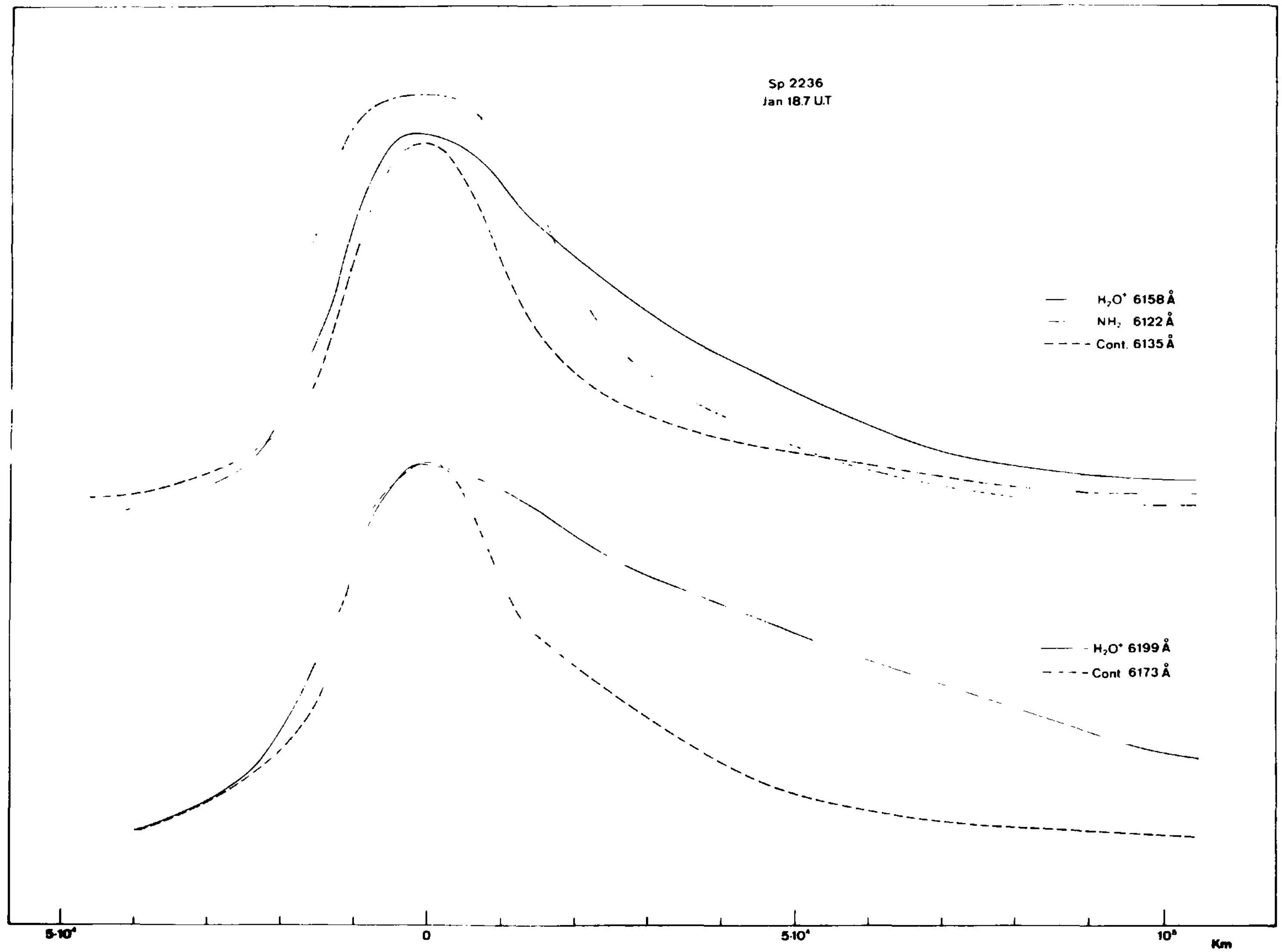

Fig. 3 - Microphotometric tracings, normal to the dispersion, of two H_2O^+ lines and of the adjacent continuum. The profile of NH_2 at 6122 Å is also reported.

H_2O^+ emissions dominate also the tail spectrum: this was roughly evident when red Schmidt plates of the Comet showed sharp filaments of the type I tail over the smooth dust tail. This was confirmed by some spectra taken in the tail at distances from the nucleus ranging from 5.5 x 10^5 Km to 1.4 x 10^6 Km (spatial resolution was achieved by offset guiding on the nucleus). Fig. 4 shows two of these spectra, and Fig. 5 reports the slit positions on a blue photograph taken at the same time with the 90/60 cm Schmidt telescope. At this heliocentric distance (r = 0.70 A.U.) also CO^+ emission was fairly strong and traces of C_2 and CN were present at about 8.2 x 10^5 Km from the nucleus. Spectrum No 2232, normal to the radius vector, shows that the more prominent tail stream of Jan 17th had very sharp edges, suggesting a bounded structure. The evolution of this feature can be followed in the plates of Jan 16th and 19th (Figs. 6,7): on the latter date it became unstable and a screwlike structure appeared. It would be very interesting to match these photographs with other plates (if available somewhere) taken at intervals of a few hours.

Besides the H_2O^+ emission, another peculiarity of Comet Kohoutek was the appearance of the [OI] forbidden lines at λλ 6300 - 6364 Å, already at heliocentric distance r = 1.55 A.U. (Comet emissions were clearly visible in short exposure spectra, although our dispersion were too low to show any Doppler shift from the night sky lines). The [OI] emissions are present in all our sample and became

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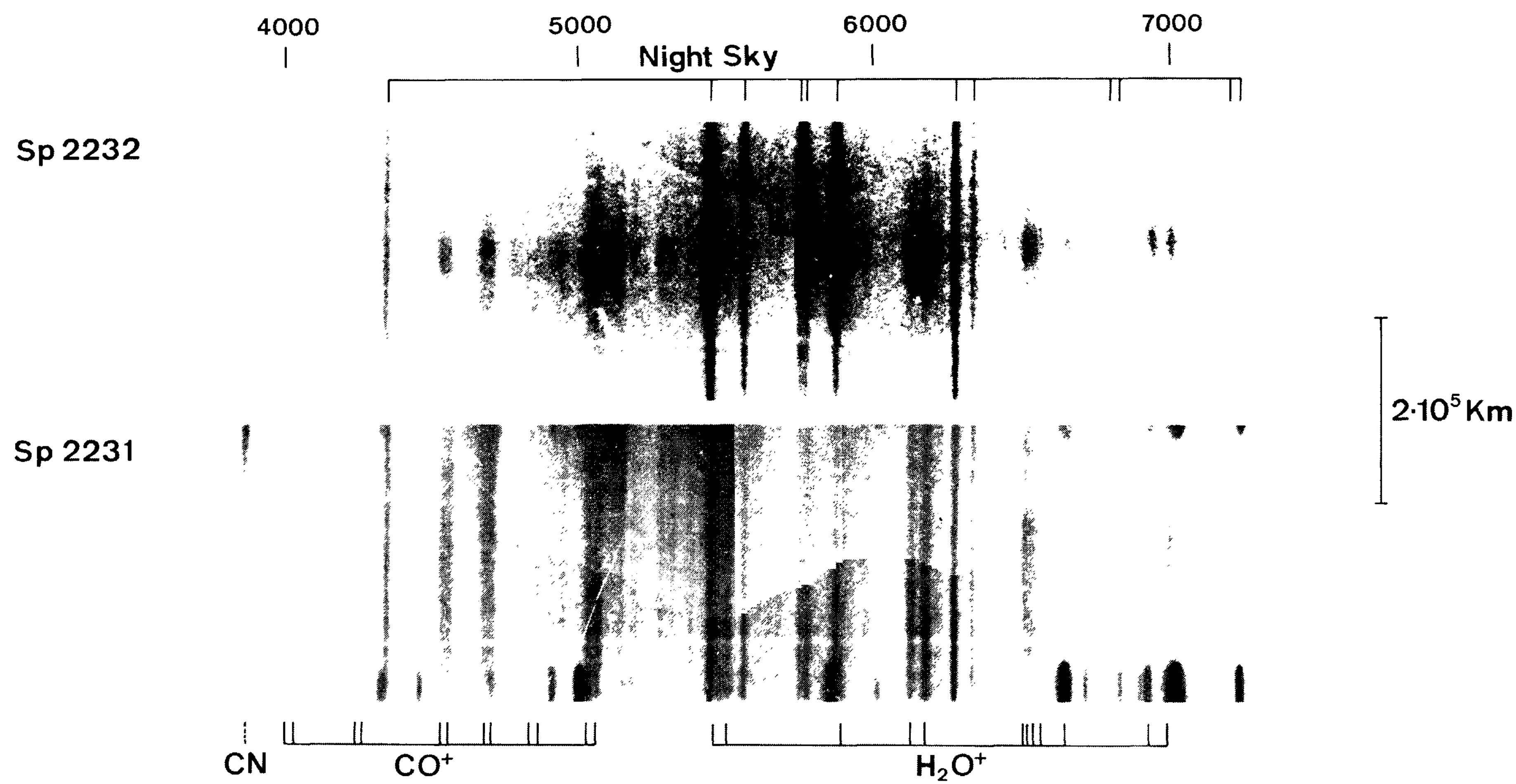

Fig. 4 - Tail spectra of Comet Kohoutek. The slit was centered at 8.2 x 10^5 Km from the nucleus, along the radius vector for Spectrum No 2231, perpendicularly to it for Spectrum No 2232.

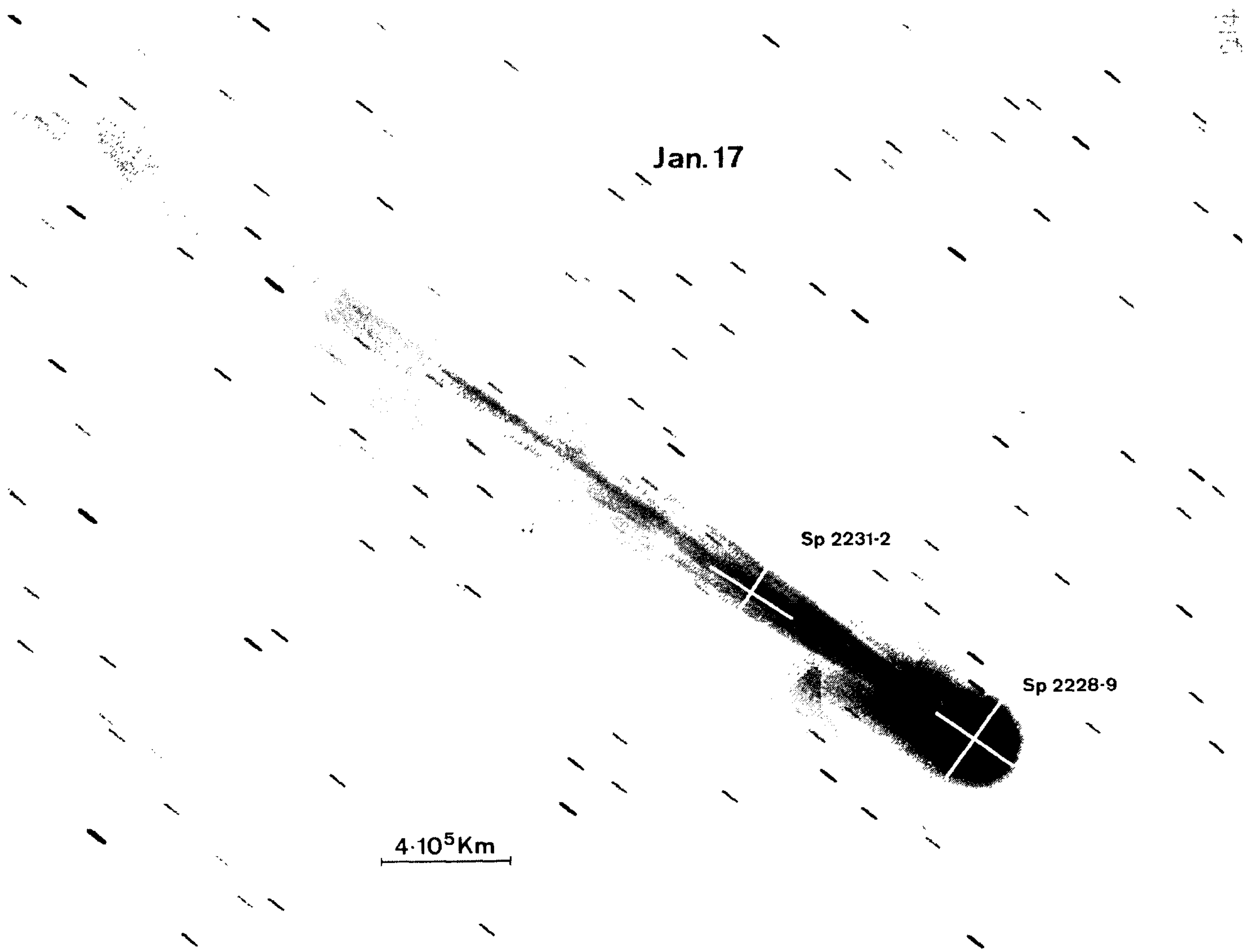

Fig. 5 - Comet Kohoutek. Asiago 90/60 cm Schmidt Telescope, Jan 17.76 U.T., 103a-O, 15^m exposure. Slit positions of Spectra Nos 2228-9 and 2231-2232 are reported.

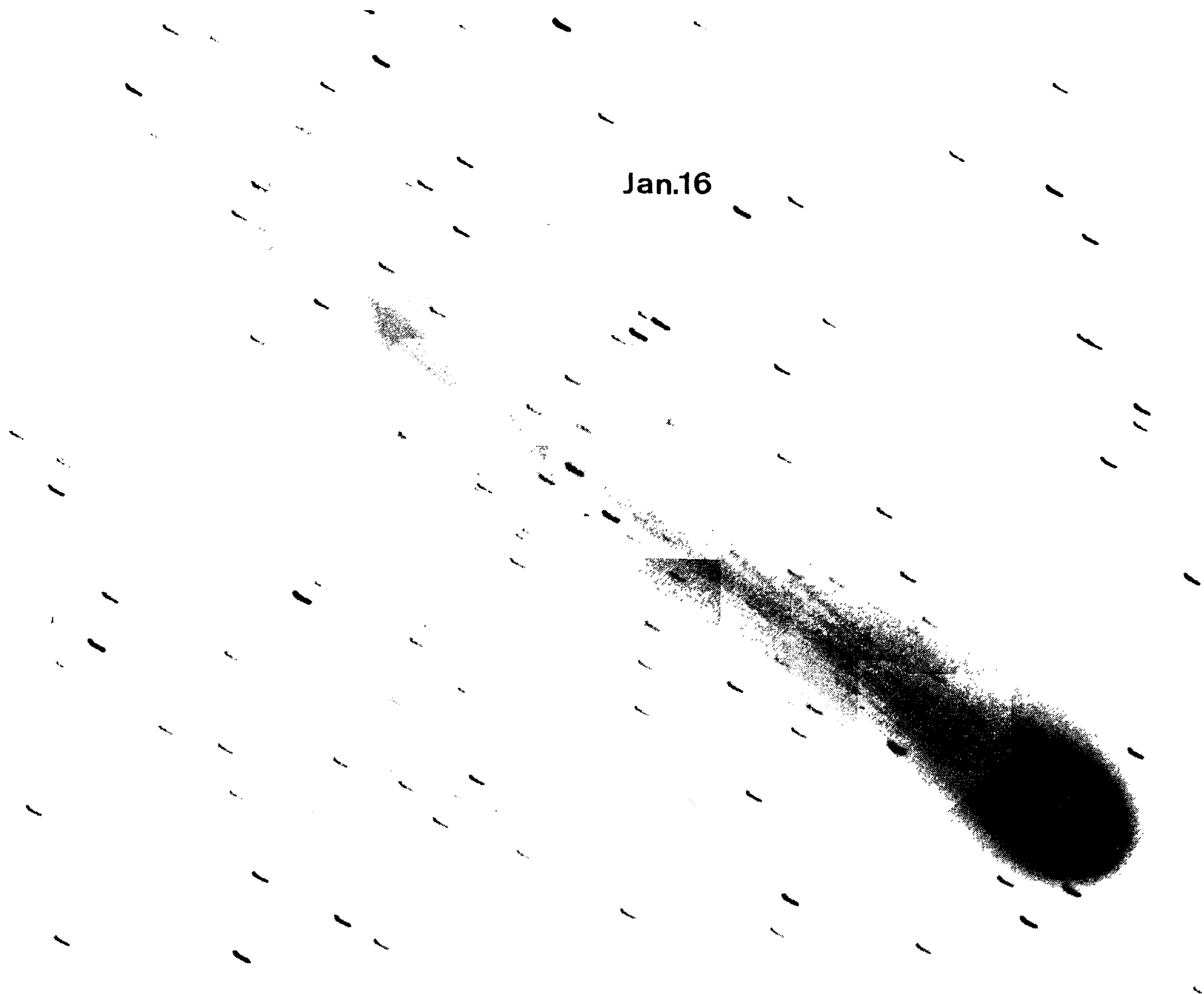

Fig. 6 - Comet Kohoutek. Jan 16.75 U.T. (data as Fig. 5)

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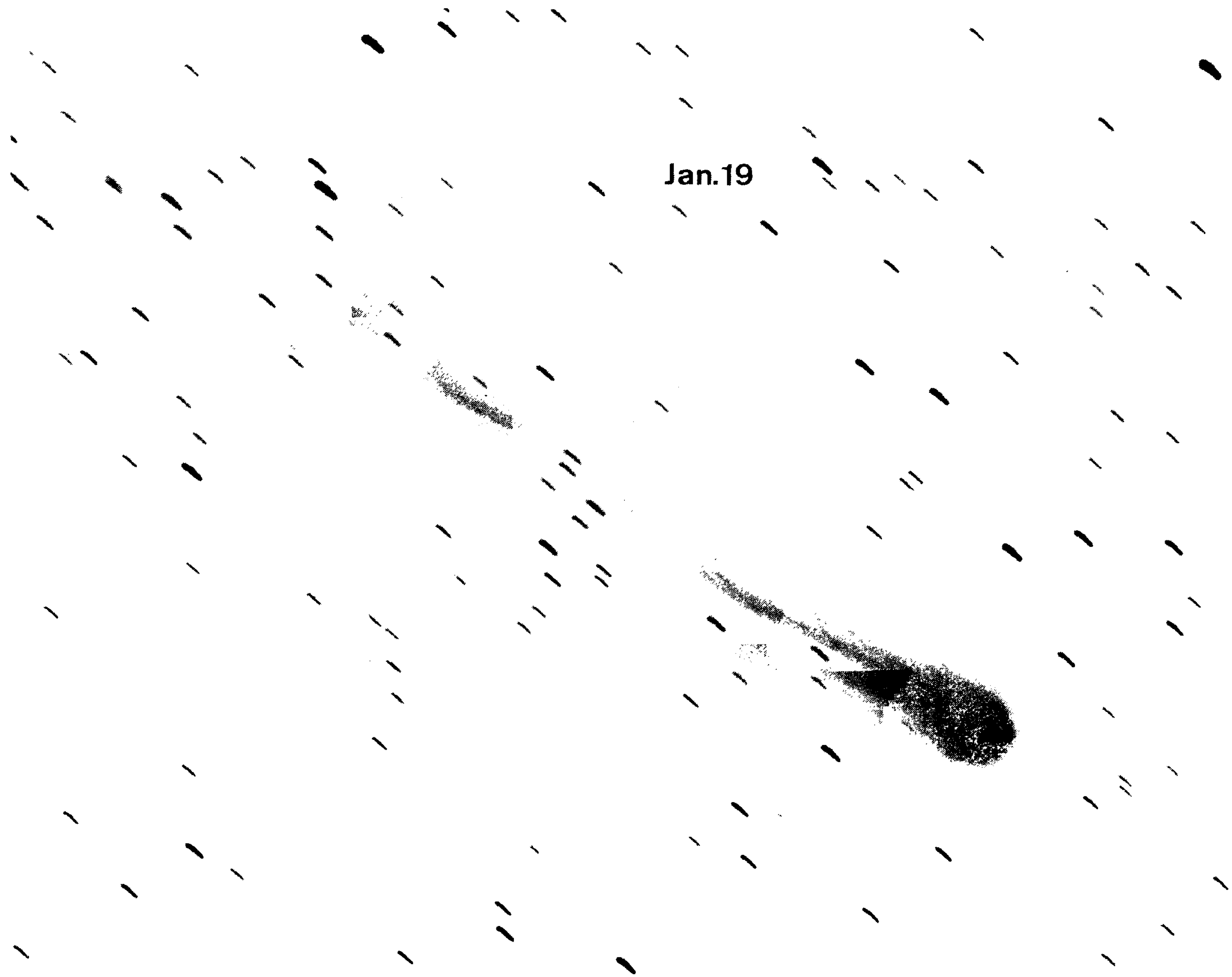

Fig. 7 - Comet Kohoutek. Jan 19.75 U.T. (data as Fig. 5)

fairly strong at r 0.80 A.U.. CO^+ was rather poor in Comet Kohoutek: its emissions are present only in the spectra of Jan 17th, 18th and 23rd at heliocentric distances of 0.70, 0.73 and 0.85 A.U., respectively.

Comparing these spectroscopic data with those of other comets the question arises if we are dealing with a peculiar comet or if the observed discrepancies are merely due to a lack of information about the red spectrum of previous comets. Although an answer will be achieved only with new data on future comets, we report here (Fig. 8) a tail spectrum of Comet Bennet (1969i) at r = 1.1 A.U.. The CO^+ emission is clearly visible but no H_2O^+ features can be detected, suggesting that some difference in chemical abundances or in physical conditions must exist.

The author is much indebted to Drs. Herzberg and Lew for useful communications.

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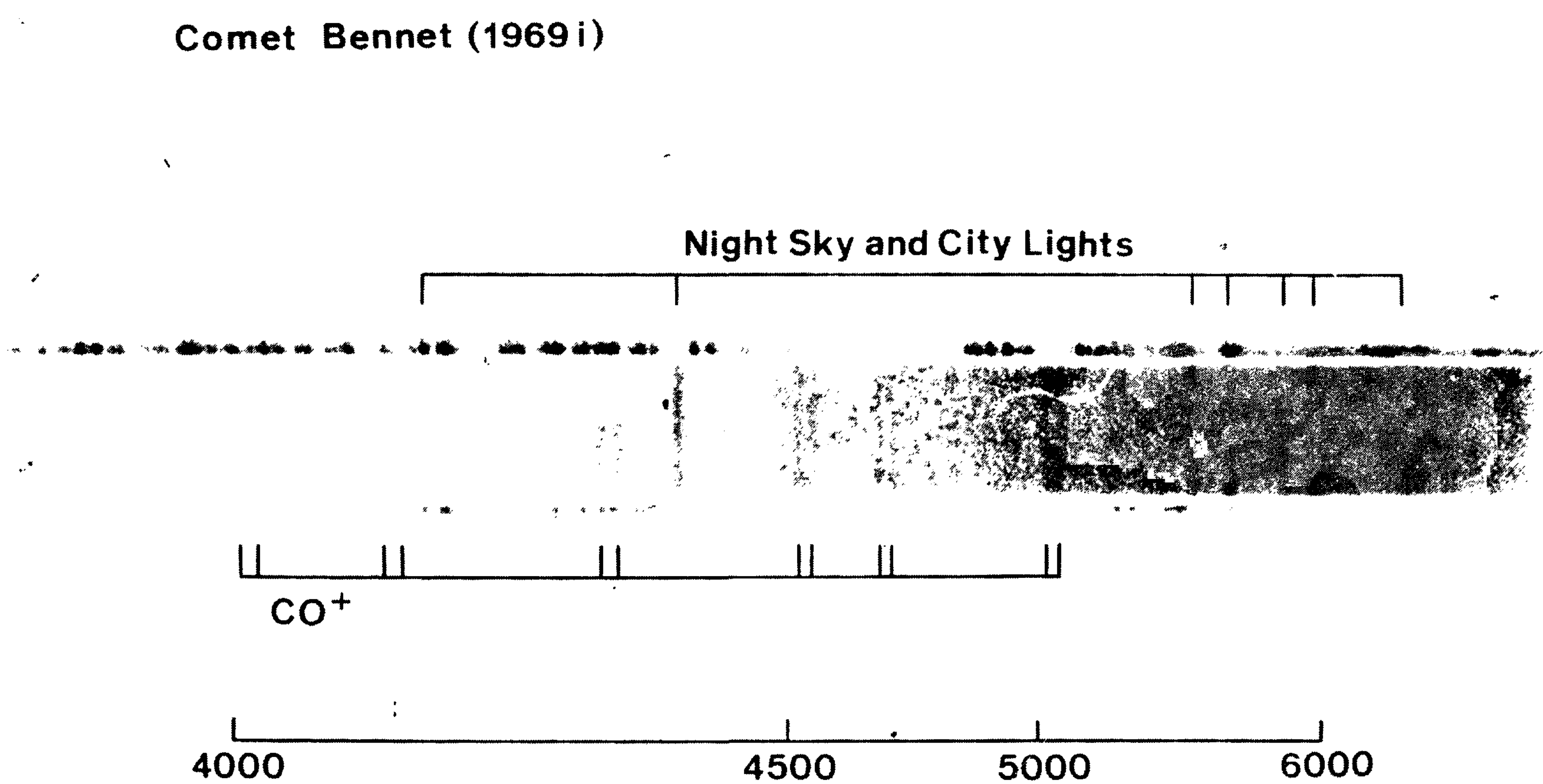

Fig. 8 - Comet Bennet (1969i). Tail spectrum, May 3.30 U.T., 1970. The slit was put normal to the tail at about 6.2 x 10^5 Km from the nucleus. Heliocentric distance r = 1.1 A.U.

DISCUSSION

G. Herzberg: I was going to ask Dr. Herbig, and perhaps Benvenuti can comment on that, too.

Dr. Herbig told us that in his spectra H_2O^+ is strongest at the head, if I understood correctly.

D. H. Herbig: Correct.

G. Herzberg: Now my question is, what about CO^+, is it also strongest at the head?

D. H. Herbig: I don't know. It wasn't in the region of the spectrum we photographed.

G. Herzberg: Would you be able to tell?

P. Benvenuti: In the region near the nucleus?

It is very difficult to say because my spectra are overexposed near the nucleus.

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