SCANNER OBSERVATIONS OF COMET P/CROMMELIN 1818I

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Abstract. Spectral scans of the coma of comet P/Crommelin 1818I have been obtained in the wavelength range λλ3200–6500 Å. Strong emission features of CN(λ3883 Å) and C_2 Swan bands (λ4695, λ5165, and λ5538 Å) have been identified. Some weak emission features of CH(λ3890 Å), C_3(λ4050 Å), CN(λ4200 Å), and C_2 + CH(λ4358 Å) were also detected. Sodium was found to be absent in this comet. An estimate of CN and C_2 abundances has been made and their production rate have been derived.

1. Introduction

The comet P/Crommelin, being of historical interest, attracted the attention of a large number of astronomers during its return in 1983. The historical details of this comet are given by Marsden (1984). This comet has an orbital period of 27.7 years. Marsden (1984) has shown that comet P/Crommelin possibly has a slightly negative transverse nongravitational component. The absence of such nongravitational effects can indicate a comet to be essentially inert. Such absence can also indicate that the comet's axis of rotation is essentially in the plane of its orbit (Marsden, 1984).

All previous observations of P/Crommelin were made within 1.1 AU of the Sun. The crude existing photometry suggests considerable variation of brightness with heliocentric distance (Marsden, 1984). During its earlier returns (in 1818, 1873, 1928, and 1956) the motion of comet P/Crommelin has a record of gravitational stability during the nineteenth and twentieth centuries. The 1983 return (Kohoutek *et al.*, 1983) on August 9–13 confirmed that the nongravitational forces on comet P/Crommelin continue to be very small which indicates the comet to be inert.

2. Observations

During the IHW trial run on comet P/Crommelin, many observers attempted to obtain observational data on this peculiar object. The comet was in a very difficult position for observations from the northern hemisphere during the actual week of the trial run. We also planned to observe this comet in February and March, 1984. We tried to observe it on many nights but the observations were hampered by clouds. As a result, we were able to observe comet P/Crommelin on only two nights. The basic data of the comet are given in Table I.

The spectral scans of the comet were secured on March 4 and 5, 1984 at the Cassegrain focus ($f/13$) of the 104 cm telescope of the observatory. The Hilger and Watts scanner giving a dispersion of 70 Å mm^{-1} in the first order was used for

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TABLE I

Basic data of comet P/Crommelin 1818I

Date (UT) March, 1984	Geocentric distance Δ (AU)	Heliocentric distance r (AU)	m_1	Radius of the circular region in the sky at distance Δ (km)	Area of the sky at distance Δ admitted through the diaphragm (km^2)
4.6	0.855	0.780	9.27	1.2677×10^4	20.19×10^8
5.6	0.848	0.788	9.30	1.2807×10^4	20.61×10^8

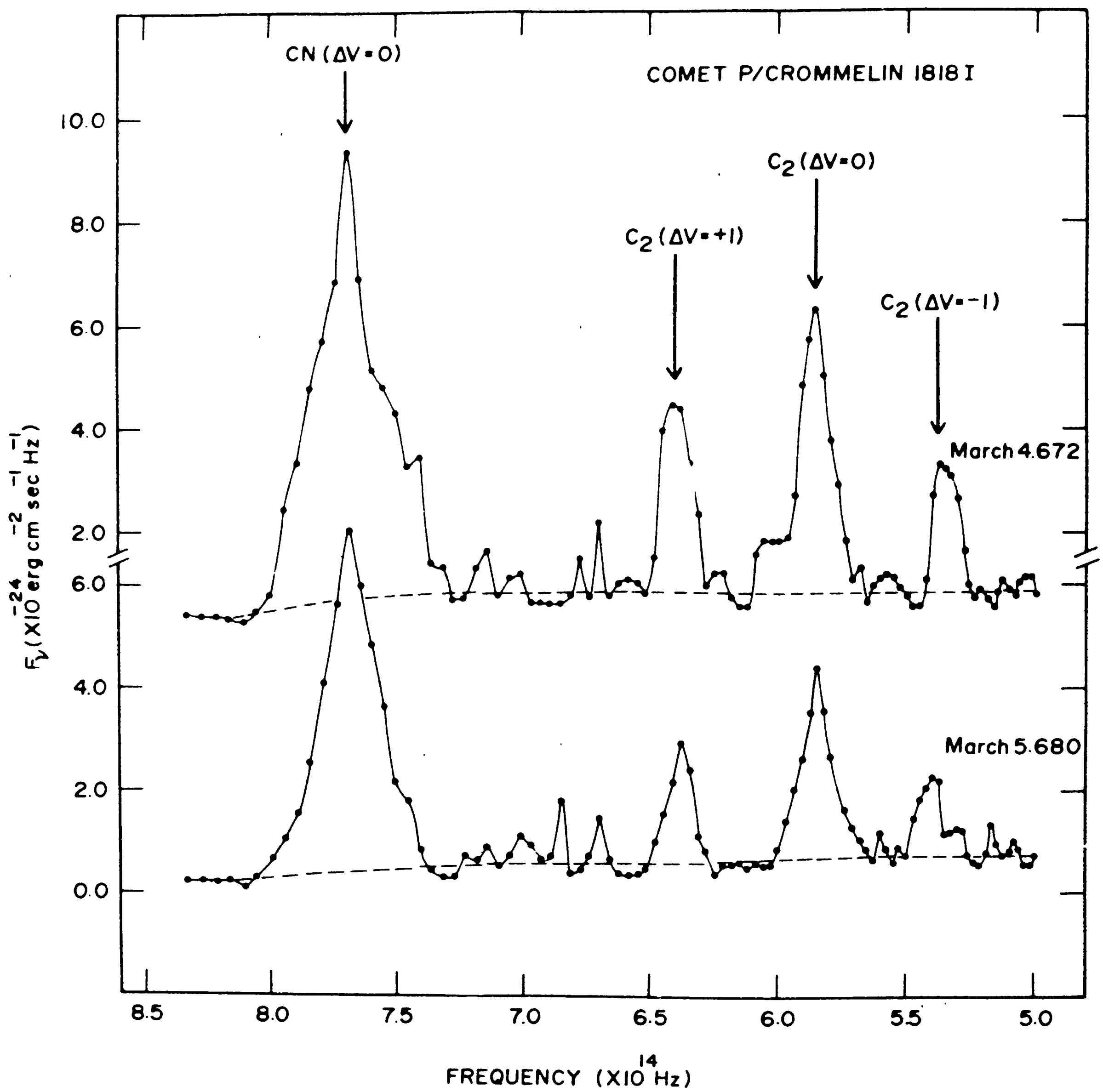

Fig. 1. Flux distribution of comet P/Crommelin 1818I. The dashed lines represent the continuum level.

TABLE II

Observed fluxes of emission bands relative to $C_2(\Delta V = 0)$

Date (UT) March, 1984	Apparent flux $F(C_2, \Delta V = 0)$ erg cm^{-2} s^{-1}	$F/F(C_2, \Delta V = 0)$				
		CN(ΔV=0)	$C_2(\Delta V = +1)$	$C_2(\Delta V = 0)$	$C_2(\Delta V = -1)$	Luminosity (L) of $C_2(\Delta V = 0)$
4.6	9.50×10^{-11}	4.36	0.92	1.00	0.56	1.937×10^{17}
5.6	6.13×10^{-11}	3.00	0.51	1.00	0.35	1.229×10^{17}

obtaining the observations. A circular diaphragm of 3 mm aperture corresponding to 45 arcsec as projected on the comet was adopted. An exit slit of 50 Å band pass was used for scanning the spectrum. The other instrumental details have already been described (Goraya *et al.*, 1982). A cooled (−20°C) EMI 9658B photomultiplier and standard d.c. techniques were employed for detecting and recording the signal.

Along with comet P/Crommelin the standard star γ Gem was observed for standardising the observations of the comet. The observations were corrected for atmospheric extinction and were reduced to absolute fluxes with the help of the standard star. The absolute flux values correspond to the recent calibration of the standard star (Taylor, 1984). The absolute flux distributions of the comet on both nights are shown in Figure 1. Since the observations were made near the horizon, the errors due to large values of air mass may be of the order of 0.20 magnitude in the observed fluxes.

3. Emittance of Emission Bands

Figure 1 shows the final spectra of comet P/Crommelin as observed during 1984. The most prominent emission features noticed from the spectral scans are: the CN(λ3883 Å) and C_2(λ4695, λ5165, and λ5538 Å). CN(λ3883 Å) is the strongest emission feature in the whole spectrum followed by C_2(λ5165 Å), C_2(λ4695 Å), and C_2(λ5538 Å), respectively, in strength. The CN(λ3883 Å) was seen to be merged with CH(λ3890 Å) and C_3(4050 Å). Very weak emission features of CN(λ4200 Å) and C_2 + CH(λ4358 Å) were also detected in the scans. No trace of sodium emission was seen in the spectrum. The strong emission features are indicated by vertical arrows in Figure 1.

For measuring the total emission at a particular band, the continuum in the spectrum was located by selecting wavelength regions free of emission lines. The area of the strong emission bands were planimetered and converted into the fluxes. The intensities of the emission bands relative to $C_2(\Delta V = 0)$ are listed in Table II. The observed flux of the $C_2(\Delta V = 0)$ band is given in the second column. The total luminosity (L) of $C_2(\Delta V = 0)$ is given in the last column of Table II.

TABLE III
Number of CN and C_2 molecules

Band	f	p	$\varrho(\nu, r)$ (erg cm^{-3})	log N
CN($\Delta V = 0$)	0.0342[a]	0.9200[b]	$4.124 \times 10^{-20}\, r^{-2}$[b]	29.42
C_2($\Delta V = +1$)	0.0089[b]	0.2409[b]	$7.140 \times 10^{-20}\, r^{-2}$[b]	29.65
C_2($\Delta V = 0$)	0.0239[a]	0.7335[b]	$6.445 \times 10^{-20}\, r^{-2}$[b]	29.03
C_2($\Delta V = -1$)	0.0071[b]	0.2142[b]	$8.390 \times 10^{-20}\, r^{-2}$	29.54

References:
[a] Lambert (1978);
[b] Goraya *et al.* (1982).

4. Number of CN and C_2 Molecules

The total number of molecules contributing to any emission band have been computed from the well-known relation (cf. O'Dell and Osterbrock, 1962) used in our earlier paper (Goraya *et al.*, 1984). The values of f, p and $\varrho(\nu, r)$ used in our calculations are given in Table III along with their sources. The total number of molecules estimated by us are listed in Table III.

5. Production Rates of CN and C_2 Molecules

The production rates (Q) of CN and C_2 molecules are derived under the assumptions and the relation used by us previously (Goraya *et al.*, 1986). The values of g and τ used in our calculations are given in Table IV. The production rates of CN and C_2 molecules are tabulated in Table V.

6. Discussion

Comet P/Crommelin was chosen as the best candidate to observe prior to comet Halley. During the trial run on this comet, many observers tried to obtain different kinds of data on it. The comet was observed successfully all over the world by a large

TABLE IV
Lifetimes and emission rate factors of CN and C_2 species

Species	Emission rate factor (g)[a] (photon s^{-1} mol^{-1})	Lifetime[b] τ (s)	Product ($g\tau$)
CN	7.42×10^{-2}	14.8×10^{4}	1.098×10^{4}
C_2	4.38×10^{-2}	6.6×10^{4}	2.891×10^{3}

References:
[a] Newburn and Johnson (1978);
[b] A'Hearn and Cowan (1975).

TABLE V

Production rates of CN and C_2 molecules

Date (UT) March, 1984	log Q (CN)	log Q (C_2)		
		C_2 ($\Delta V = +1$)	C_2 ($\Delta V = 0$)	C_2 ($\Delta V = -1$)
4.6	25.00	24.90	25.13	24.69
5.6	24.83	24.64	24.93	24.48

number of astronomers. The preliminary reports of different kinds of observations have been given in *IHW Newsletter*, No. 5. In all, the comet was observed in the wavelength range λλ3000–8000 Å. Spinrad and Djorgovski (1984) observed [O I] at λ6300 Å and 6364 Å and detected numerous NH_2 emission bands on February 29, 1984.

Larson (1984) obtained spectra of comet P/Crommelin on February 1 and 2, March 1 and 2. He observed emission bands of OH, NH, CN, C_3, CH, C_2 Swan system and NH_2. Spinrad *et al.* (1984) obtained long slit spectra on February 4 and 24, March 2 and 3. They observed the usual emission features of C_2 Swan system and CN(2–0), with unusually strong NH_2 emission features. Lutz *et al.* (1984) also observed strong emission features of C_2 Swan system, CN, NH_2, C_3 etc. on February 21, March 26 and 29. The usual features were observed by many other observers (Lub and de Grijpe, 1984).

A'Hearn *et al.* (1985) observed comet P/Crommelin over a wide heliocentric distance range. They noticed asymmetry of production rates about perihelion. They found that the asymmetry about perihelion seen in CN is much smaller than that seen in OH, C_2 and C_3.

The predicted brightness of comet P/Crommelin (Festou, 1983; Morris, 1983) for the 1984 apparition was found to be inconsistent with the actual observed 1984 light curve (Marcus, 1984; Bortle, 1984; Morris, 1984). From the analysis of the observed light curve during the interval January 1–April 2, 1984 given by Festou (1985) it can be concluded that (i) the maximum brightness of the comet was on 25 February ± 2 days, (ii) no obvious large outbursts occurred, and (iii) the activity of the nucleus was quite erratic and some bursts as well as some activity decreases of ~ 0.5 magnitude seem to be real.

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