SPECTROPHOTOMETRIC STUDY OF COMET BRADFIELD (1987s)

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Abstract. Spectrophotometric observations of head of comet Bradfield (1987s) during three nights in 1987 are presented. An estimate of the CN, C_2, and C_3 column densities and production rates have been made.

1. Introduction

Comet Bradfield (1987s) was discovered on 11 August, 1987 by William A. Bradfield when its magnitude was around 10. Total visual magnitude estimates, precise positions and orbital elements for the comet were reported by many observers. Infrared observations by Lynch and Russell (1987) showed silicate emission features. We observed the comet spectrophotometrically and identified the molecular emission features due to CN, C_2, and C_3.

2. Observations

The comet was observed on three nights with spectrum scanner, mounted at the Cassegrain focus ($f/13$) of the 104 cm reflector. A circular diaphragm of 3 mm which corresponds to 45 arc sec as projected on the sky, allows light from the head of the comet to be observed. An exit slit of 0.7 mm allowing 50 Å of the spectrum to fall on the photomultiplier was used. At least three spectral scans of the comet were obtained every night and were reduced to instrumental magnitude. The mean of the instrumental magnitudes were adopted. Scans of the neighbouring sky taken before and after scans of the comet enabled elimination of the contribution by the background sky.

The standard star ξ^2 Cet. was observed to check the wavelength calibration of the scannar, and to standardise the observations of the comet. The observations were corrected for atmospheric extinction and were reduced to absolute values. The absolute values of the fluxes thus obtained correspond to Taylor's (1984) calibration of α Lyr. The absolute flux distribution of the comet for the three nights is shown in Figure 1. The prominent emission features, as can be seen in Figure 1, are CN ($\Delta V = 0$) at 388.3 nm, C_2 ($\Delta V = +1, 0, -1$) at 469.5, 516.5, and 553.6 nm respectively. Weak emission features due to $CH + C_3$ at 405 nm is also present. The continuum in the spectrum was located by selecting wavelength regions free of emission bands. The area of the emission bands was measured and converted into total flux. Emission band flux relative to C_2 (516 nm) are listed in Table II.

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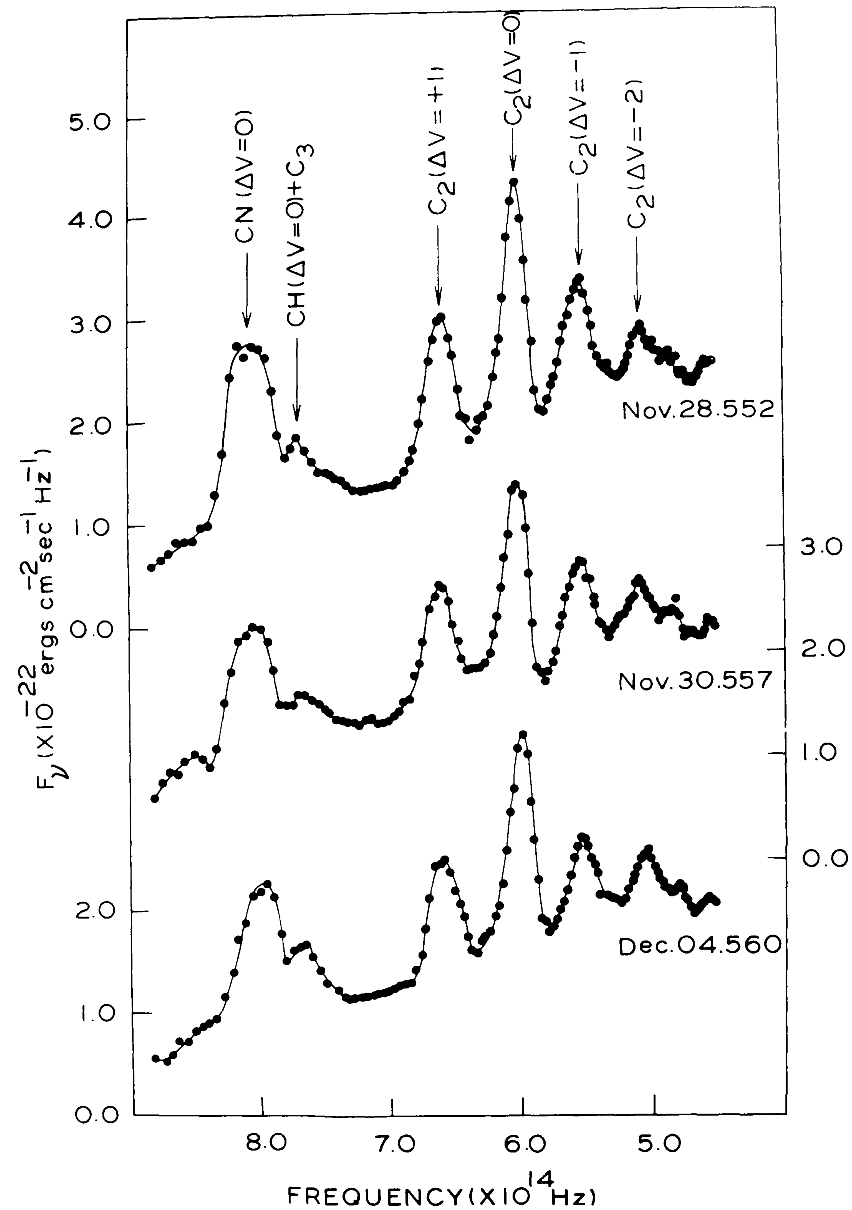

Fig. 1. Absolute flux distribution of the head of Comet Bradfield (1987s).

TABLE I

Basic data for Comet Bradfield (1987s)

Date 1987 (UT)	Geocentric distance Δ(AU)	Heliocentric distance r(AU)	Radius of the circular region in sky at distance (Δ) $\times 10^4$(km)	Area of the sky at distance Δ admitted through diaphragm $\times 10^8$(km^2)
Nov.28.552	0.882	0.953	1.44	6.51
Nov.30.557	0.870	0.968	1.42	6.33
Dec.04.560	0.850	1.002	1.39	6.07

TABLE II

Emission band fluxes relative to $C_2(516)$, $\Delta V = 0$

Date 1987 (UT)	Apparents $F(C_2, \Delta V = 0)$ (ergs cm^{-2} sec^{-1}) $\times 10^{-9}$	$F/F(C_2, \Delta V = 0)$					
				C_2			
		$CN(\Delta V = 0)$	$C_3(\Delta V = 0)$	$\Delta V = +1$	$\Delta V = 0$	$\Delta V = -1$	$\Delta V = -2$
Nov.28.552	4.98	1.565	0.510	0.709	1.000	0.574	0.205
Nov.30.557	4.36	1.204	0.440	0.779	1.000	0.516	0.221
Dec.04.560	4.15	1.241	0.446	0.624	1.000	0.376	0.205

TABLE III

Column densities (M) and production rates (Q)

Date 1987 (UT)	log(M)					log (Q)			
	$CN(\Delta V = 0)$	$C_3(\Delta V = 0)$	$C_2(\Delta V = 1)$	$C_2(\Delta V = 0)$	$C_2(\Delta V = -1)$	CN	C_2	C_3	dust
Nov.28.552	31.500	30.527	31.466	31.350	31.408	27.29	27.42	26.07	12.44
Nov.30.557	31.350	30.407	31.450	31.294	31.334	27.15	27.37	25.94	12.38
Dec.04.560	31.327	30.401	31.343	31.282	31.185	27.13	27.29	25.95	12.41

3. Column Densities and Production Rates

The number of molecules of each observed species, contained in a cylinder of radius defined by the diaphragm, used and extending entirely through the coma was evaluated using the standard formula by Millis *et al.* (1982) $\log M(\rho) = \log F(\rho) + 27.449 + 2\log(\Delta r) - \log g$; where F is the observed flux in cgs units, r and Δ are the heliocentric and geocentric distances of the comet respectively in AU, and g the fluorescence efficiency (in cgs units) per molecule at 1 AU. We used the values of fluorescence efficiency for C_2 and C_3 from Sivaraman *et al.* (1987). Because of the Swings effect, $g(CN)$ varies significantly with the comets heliocentric radial velocity. To calculate radial velocity the orbital elements for the comet were taken from the IAU Cir: No. 4483 and value of g was obtained from the figure of Tatum and Gillespie (1979). The column densities obtained are listed in Table III. The column densities thus calculated were converted into production rates (Q), assuming a Haser models through the relation given by A'Hearn and Cowan (1975) as

$$M(\rho) = Qv^{-1}\rho\left[\int_x^{\mu x} K_0(y)\,dy + \frac{1}{x}\left(1 - \frac{1}{\mu}\right) + K_1(\mu x) - K_1(x)\right],$$

where V = velocity of released species, μ = ratio between daughter and parent molecules scale-lengths, x = ratio between ρ and daughter molecules scale-lengths. K_0 and K_1 are modified Bessel functions of the second kind of order 0 and 1. Following Delsemme (1982) we assumed $V = 0.58/\sqrt{r}$. The parent and daughter molecule scale lengths were taken from Cochran (1985). Bessel functions were calculated using the tables of Abramowitz and Stegun (1964) and the extrapolation formula therein. The resulting production rates are given in Table III. An arbitrary measure of the solid particle production rate was calculated using the equation given by A'Hearn *et al.* (1979).

$$\log(Q)\ (\text{Solids}) = \log L_\lambda(5240) + 2\log r - \log \rho,$$

where L_λ is luminosity at wavelength 5240 Å.

The dust production rates evaluated are listed in Table III.

4. Discussion

The production rates of various molecular species have been plotted in Figure 2, against the heliocentric distance. The straight lines have been fitted by free hand. The molecular species C_2, C_3, and CN show a systematic variation with the heliocentric distance r. In this figure we note that the dust production rate is almost constant at different heliocentric distances which indicate that unlike the molecular species the dust production rate is independent of r.

A'Hearn and Millis (1977) point out that the ratio of CN and C_2 production rate is remarkably constant between 0.3 and 0.5. Comet Bradfield (1987s) gives a

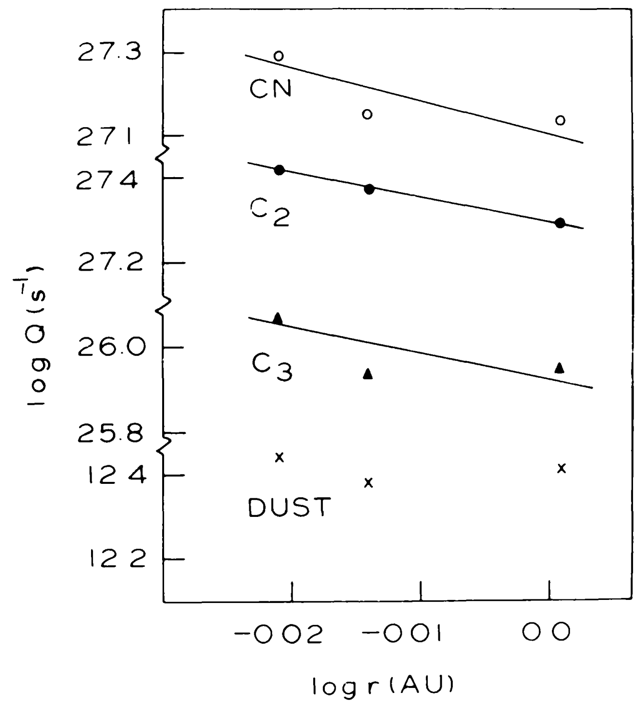

Fig. 2. The production rates of CN,C_2,C_3 molecules and dust as a function of heliocentric distance.

higher value of the said ratio $[Q(CN)/Q(C_2) = 0.68]$ indicates that the CN is over abundant with respect to other comets. A'Hearn *et al.* (1979) also found an over abundance of CN in comet P/Grigg-Skjellerup $[Q(CN)/Q(C_2) = 1.38]$.

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