# SPECTROPHOTOMETRIC STUDY OF COMET AUSTIN (1989 C1)

B. S. RAUTELA and B. B. SANWAL
*Uttah Pradesh State Observatory, Manora Peak, Naini Tal, India*

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**Abstract.** Spectrophotometric observations of the head of comet Austin (1989 C1) during five nights in May 1990 are presented. Emission bands due to CN, $C_2$ and $C_3$ molecules have been identified. An estimate of their column densities and production rates have been made.

## 1. Introduction

Comet Austin (1989 C1) was discovered by the New Zealand astronomer Rodney Austin on December 6, 1989. The comet brightened steadily reaching 8th magnitude by early February 1990. The apparent total magnitude ($m1$) of comet Austin as a function of its distance $d$ from the Earth and $r$ from the sun followed the brightness formula

$$m1 = 4.5 + 5\log(d) + 10\log(r)$$

According to this formula at parihelion passage on April 9, the comet was expected to attain magnitude 0. McNaught (1990) however derived a brightness law which satisfied 28 observations of comet Austin and predicted a magnitude of −3.3 at perihelion, but its display was very disappointing as it happened in the case of comet Kohoutek (1973 XII) also. Thus we see that the cometry brightness is notoriously unpredictable.

The comet was observed in radio, infrared, visual and ultraviolet wave bands. Some of them are mentioned here.

Wallis (1990) reported that the ultraviolet spectrum obtained with IUE showed usual OH, $C_2$, CS and 290–300 nm molecular continuum, OH was unexpectedly strong and $H_2O$ production rate was similar to P/Halley preperihelion $H_2O$ production rate but 50% higher than P/Halley preperihelion $H_2O$ production rate, at a comparable heleocentric distance. West (1990a) on the basis of 5 min CCD exposures in R filter found amorphous coma elongated in antisolar direction on Jan 23.0471 UT. West (1990b), Gehrz and Ney (1990) reported the infrared magnitudes in January, February, and April 1990. Altenhoff *et al.* (1990) obtained continuum emission at 250 Hz, when the comet was at heliocentric distance 0.75 AU and geocentric distance 1.47 AU. This distance is probably the largest distance at which a radio signal of a comet has been detected. Schleicher *et al.* (1990) obtained production rates of $C_2$, $C_3$ and CN based on aperture photometry between December 19 and March 7, 1990. Gas-to-dust ratio was found approximately 3 times higher than was found in P/Halley at a comparable heliocentric

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TABLE I

Basic data of comet Austin (1989 C1)

| Date 1990 UT | Geocentric distance $\Delta$ (AU) | Heliocentric distance $r$ (AU) | Radius of the circular region in sky $10^4$ (km) |
|---|---|---|---|
| May 6.94 | 0.451 | 0.783 | 0.74 |
| May 7.93 | 0.434 | 0.805 | 0.708 |
| May 18.94 | 0.273 | 1.029 | 0.445 |
| May 23.88 | 0.255 | 1.130 | 0.416 |
| May 25.90 | 0.252 | 1.168 | 0.411 |

distance. Festou *et al.* (1990) observed comet Austin with the IUE during the period May 7–13, 1990. The ultraviolet spectrum was found to be characteristic of non-dusty comets. Joshi *et al.* (1990) reported the degree of polarization and position angles in filter bands of IHW filter system on May 2 and 4 on the basis of aperture polarimetry.

## 2. Obervation and Reduction

Comet Austin (1989 C1) was observed on five nights in May 1990, with a spectrum scanner, mounted at the Cassegrain focus (f/13) of the 104-cm reflector of the Uttar Pradesh State Observatory. A circular diaphragm of 3 mm corresponding to 45 arcsecs as projected on the sky and centred on the nucleus of the comet was used. An exit slit of width 0.7 mm allowing 50 A of the spectrum to fall on the detector was used. The detector was a cooled (−20 °C) EMI 9658B photomultiplier. The observing techniques and the method of reduction were the same as given by Rautela and Sanwal (1988). The standard stars $\alpha$ Lyr, $\alpha$ Leo and $\eta$ UMa were observed to check the wavelength calibration of the scanner, and to standardize 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 $\alpha$ Lyr.

The basic parameters of the comet for the days of the observations are given in Table I and the absolute flux distribution of the comet for five nights is shown in Figure 1.

## 3. Molecular Emission Bands

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 553.8 nm respectively. Emission features due to CH + $C_3$ at 405 nm and $C_2$ ($\Delta V = -2$) at 619 nm are also present. The $C_2$ ($\Delta V = 0$) emission is the strongest feature in the whole spectrum. The heliocentric distances during the period of our observations were more than

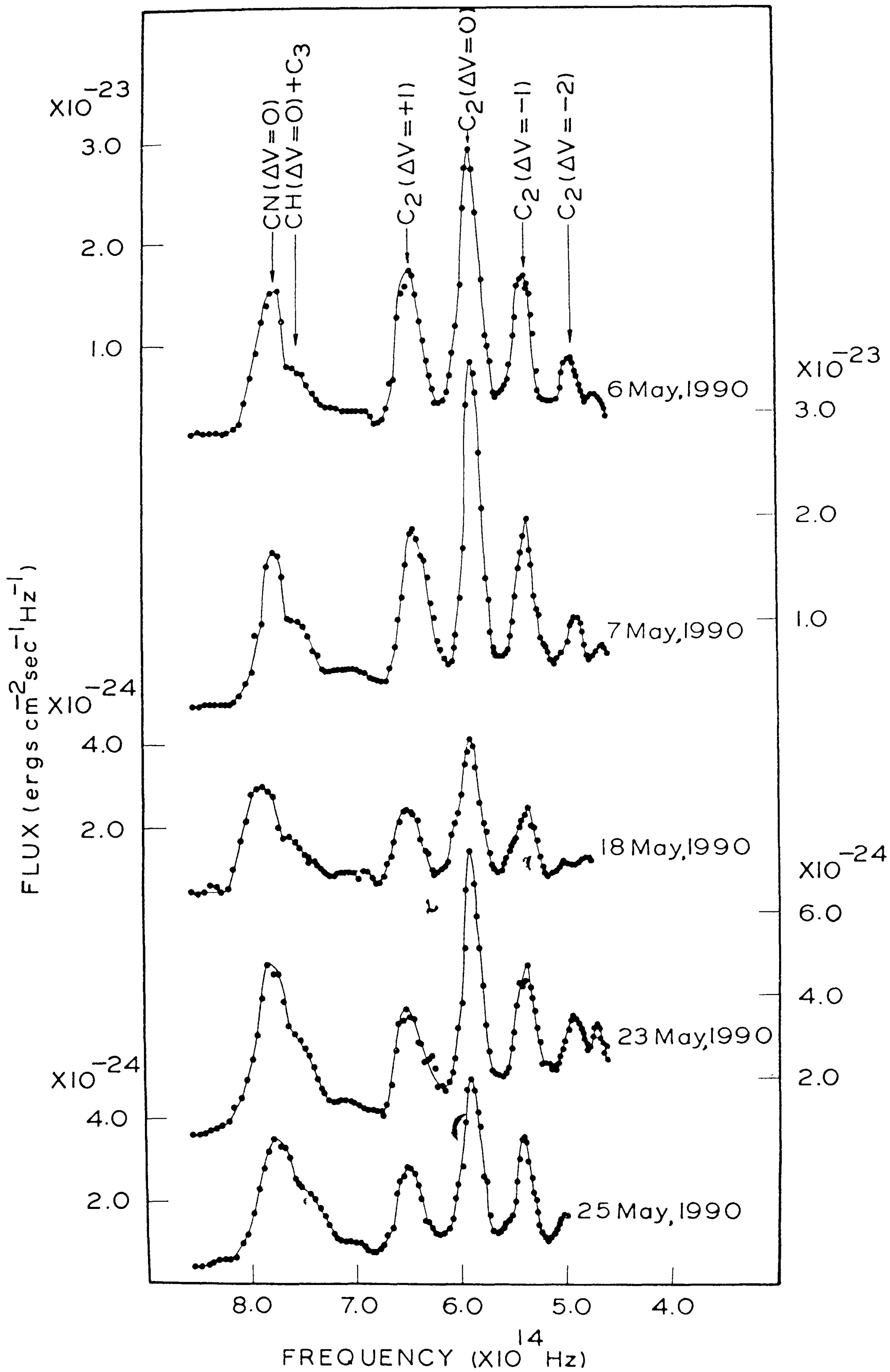


Fig. 1. Absolute flux distribution of the head of comet Austin (1989 C1).

TABLE II

Emission Band Fluxes Relative to $C_2$ ($\Delta V = 0$)

| Date 1990 UT | Apparent $F(C_2, \Delta V = 0)$ ergs $cm^{-2}$ $sec^{-1}$ $\times 10^{-10}$ | $F/F(C_2, \Delta V = 0)$ CN($\Delta V = 0$) | $C_3(\Delta V = 0)$ | $C_2(\Delta V = 1)$ | $C_2(\Delta V = -1)$ |
|---|---|---|---|---|---|
| May 6.94 | 5.608 | 0.729 | 0.346 | 0.675 | 0.453 |
| May 7.93 | 5.800 | 0.711 | 0.378 | 0.707 | 0.450 |
| May 18.94 | 0.764 | 1.196 | 0.522 | 0.627 | 0.476 |
| May 23.88 | 1.111 | 1.255 | 0.657 | 0.601 | 0.488 |
| May 25.90 | 0.798 | 1.557 | 0.813 | 0.683 | 0.529 |

0.78 AU. Sodium D line at 589 nm was expected at heliocentric distance less than 0.8 AU but we did not detect such emission in comet Austin (1989 C1).

In order to measure fluxes in the emission bands, the continuum in the scans was located by selecting wavelength regions free of emission bands. The area under the emission bands was measured and converted into the total flux. Emission band fluxes relative to $C_2$ (516 nm) are listed in Table II.

## 4. 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 $\Delta$ are the heliocentric and geocentric distances of the comet respectively in AU, and $g$ the flourescence efficiency (in cgs units) per molecule at 1 AU. We used the values of flourescence 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 IAU cir. No. 4985 and value of $g$ was obtained from the figures of Tatum and Gillespie (1977). The column densities were then converted into production rate ($Q$) through the relation given by A'Hearn and Cowan (1975)

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

where $v$ = velocity of released species, $\mu$ = ratio between daughter and parent molecules scale-lengths, $x$ = ratio between $\rho$ and daughter molecule scale lengths.

TABLE III

Column Densities (log $M$) and Production Rates (log $Q$)

| Date 1990 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 |
| May 6.94 | 29.52 | 28.66 | 28.74 | 29.65 | 29.63 | 25.79 | 26.17 | 24.57 | 10.27 |
| May 7.93 | 29.50 | 28.70 | 29.77 | 29.65 | 29.63 | 25.80 | 26.21 | 24.64 | 10.46 |
| May 18.94 | 28.61 | 28.03 | 28.64 | 28.58 | 28.59 | 25.18 | 25.40 | 24.19 | 9.66 |
| May 23.88 | 28.84 | 28.06 | 28.81 | 28.77 | 28.78 | 25.44 | 25.61 | 24.22 | 10.03 |
| May 25.90 | 28.82 | 28.02 | 28.74 | 28.64 | 28.69 | 25.43 | 25.52 | 24.19 | 9.84 |

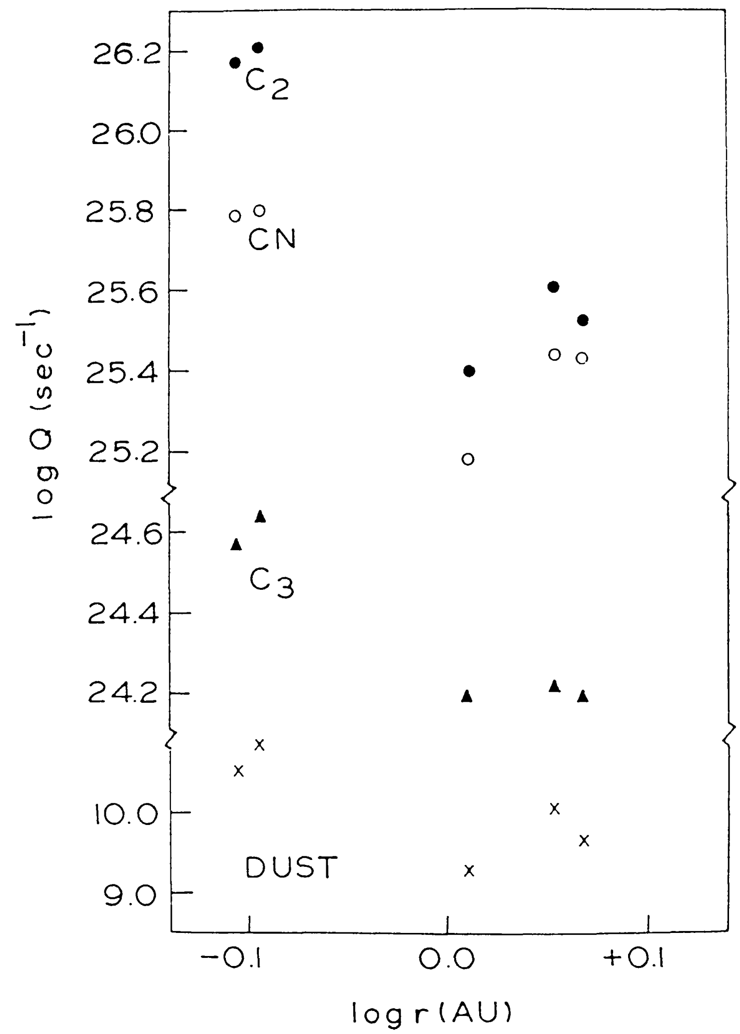


Fig. 2. The production rates of CN, $C_2$, $C_3$ molecules and dust as a function of heliocentric distance.

$K_0$ 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).

An arbitrary measure of the solid particle production rate was also calculated following the equations given by A'Hearn *et al.* (1979).

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

where $L$ is luminosity at wavelength 5240 A. The production rates and column densities thus calculated are listed in Table III.

## 5. Conclusion

The production rates of the various observed species and dust are plotted in Figure 2 against heliocentric distance for all the five nights of observations. It is interesting to note that the production rates of all molecular species as well as dust shows a sudden outburst on May 23 and 25. The night of May 18 was of poor quality and hence the reduction in the production rates on this night may not be real. However solar X-ray flux increased on May 23 and 24 as reported in the Solar Geophysical Data. The outburst in the production rates of molecular species and dust in this comet were observed after the occurance of X-ray flares in the sun. A'Hearn and Cowen (1975) also observed a similar outburst in comet Kohoutek and tried to decide whether the outburst is a phenomenon totally internal to the comet or is triggered by an external source such as sun and concluded that both the possibilities are equally plausible. However, in the case of comet Wilson (1986(1)) Sanwal and Rautela (1988) found sudden inhancement in $C_2$ and $C_3$ production rates but did not found any inhancement in CN and dust production rates. The possibility of solar triggering was believed to be the more plausible cause in that case. Thus it is difficult to decide whether the outbursts in comets is an internal phenomenon or is triggered by the sun.

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