SPECTROPHOTOMETRIC STUDY OF THE COMET P/SWIFT-TUTTLE (1992t)

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Abstract. Spectrophotometric observations of the periodic comet P/Swift-Tuttle (1992t) were taken through 104 cm telescope of Uttar Pradesh State Observatory Nainital, using EG & G spectrograph coupled with optical multichannel analyser and reticon array detector in the optical region of the spectrum, during four nights of December 1992. The molecular emission bands of CN ($\Delta\nu = 0$) at 3888 Å, CH + C_3 at 4050 Å and C_2 ($\Delta\nu = +1, 0, -1$) at 4690 A, 5160 Å and 5530 Å respectively, were identified. Column densities and production rates have been determined.

1. Introduction

Comet P/Swift-Tuttle (1992) which first appeared on July 16, 1862 has recently appeared after its 130 years of journey. Although it was predicted to return around 1981 by Marsden (1973), the comet was not recovered until the first redetection by Kiuchi (Marsden, 1992a). Marsden(1992b) predicted that the comet may hit the earth if a delay of +15 days is caused in its next perihelion return. However, Chambers (1992) suggests that the next two perihelion passages would be within a day of the predicted dates and there is no possibility of a collision with the earth. The Perseid meteor shower,which comprises dust particles ejected from comet P/Swift-Tuttle (1992t), has shown strong activity since 1991 (Yoshida *et al.*, 1993,Watanabe *et al.*, 1992), which led Marsden to predict a return of comet in 1992 (Marsden, 1991). Yoshida *et al.* (1993) have detected that this comet shows prominent activity. Several dust-jets exhibit spiral structures originating from the nucleus.

Keeping in view the scientific importance of observing the comets, we took spectrophotometric observations of this comet on four nights in December (2, 3, 7 and 8), 1992.

2. Observation and Reduction

Comet P/Swift-Tuttle was observed on four nights in December 1992, with an optical multichannel analyser mounted at the Cassegrain focus of the 104 cm telescope of U.P. State Observatory, Nainital.

The complete optical multichannel analyser system consists of a spectrograph, a reticon array detector, detector interface and system processor. All the components were acquired from EG & G Princeton Applied Reaserch, USA. The

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spectrograph gives a dispersion of 0.25 nm/element with a grating having 300 grooves/mm blazed at 500 nm. Central wavelength of the spectrum can be selected with the help of a wavelength dial.

At the entrance slit of the spectrograph a circular diaphragm of 2 mm diameter corresponding to 30 arc seconds as projected on the sky and centered on the nucleus of the comet was used. The spectrum is focussed onto a diode array detector. The diode array detector is having 1024 elements of size 2 mm × 25 microns and thus covers 2560 Å wide spectrum in a single exposure. The diode array detectors have high sensitivity. They are electronic devices which can be readout and analysed very rapidly by computerized system processor. The detector interface is a 16 bit microprocessor data acquisition system that can collect, store and even preprocess spectral data before sending it on to the system processor. The system processor is based on the Motorola 68000 microprocessor chip and is fully operational from its soft-touch screen. All the operations of data acquisition, storage, calibration, analysis etc. are performed with this system.

At least three spectral scans of the comet were obtained every night. Alongwith the comet, standard stars α-Lyr and ξ^2 Cet were also observed for determining the extinction coefficients and to standardise the observations of comet. Data were stored on floppy disk and then transfered to Vax II computer for further analysis. A computer programme was written for atmospheric extinction correction and to determine the absolute flux of observations. The absolute flux of the comet were extracted at 30 Å interval and are shown in Figure 1. The absolute values of the fluxes correspond to Taylor's (1984) calibration of α-Lyr. The geocentric distance (Δ), the heliocentric distance (r) and the predicted magnitudes of the comet on different observing nights etc. are given in Table I (B.A.S.Cir.722).

3. Molecular Emission Bands

The prominent emission features as can be seen in Figure 1 are CN ($\Delta v = 0$) at 3888 Å, CH + C_3 at 4050 Å and C_2 ($\Delta v = +1, 0, -1$) at 4690, 5160 and 5530 Å. The strongest feature in the whole spectrum is due to C2 ($\Delta v = 0$) at 5160 Å. CN band seems to be more prominent on 7th and 8th December. There is no significant change in other species. Preliminary results of this comet has already been reported by Sanwal *et al.* (1993). The area of the emission bands was measured and converted into total flux.

4. Column Densities and Production Rates

The number of molecules of each species, contained in a cylinder of radius defined by the diaphragm used, and extending entirely through the coma was evaluated using the formula by Millis *et al.* (1982):

$$\log M(\rho) = \log F(\rho) + 27.449 + 2\log(\Delta r) - \log g\,,$$

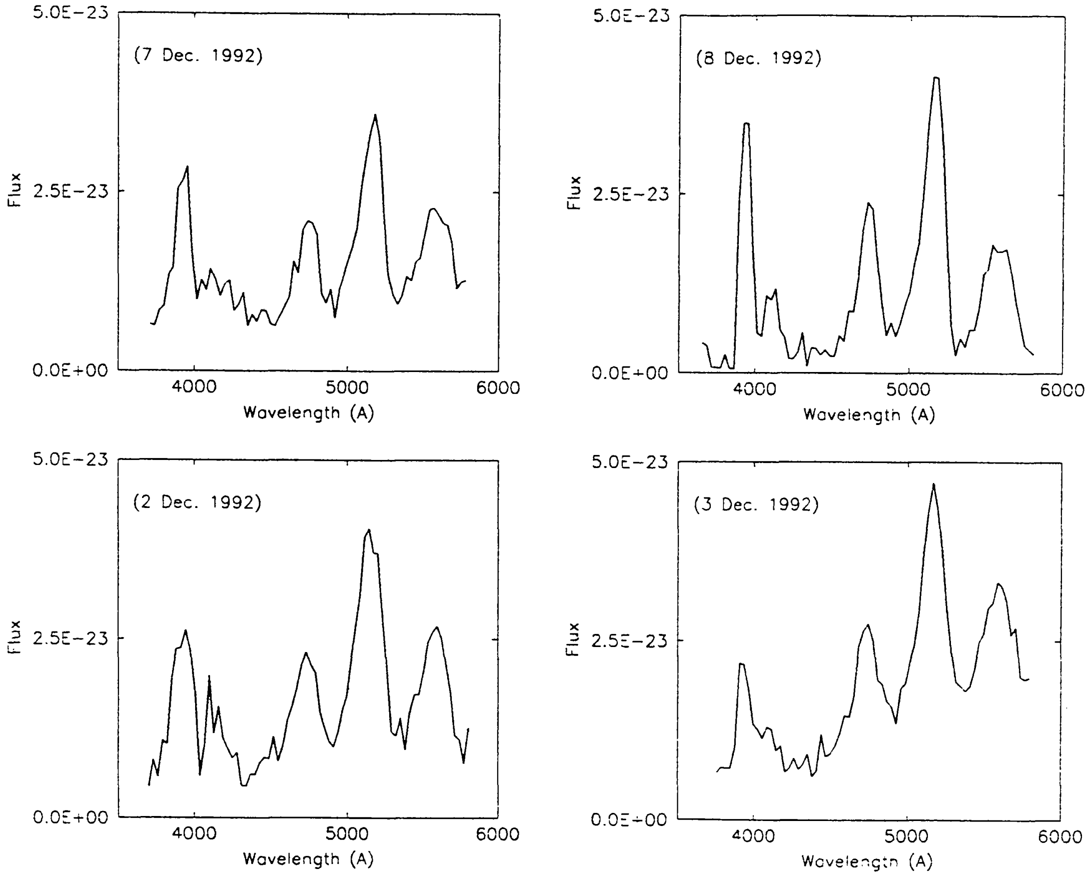

Fig. 1. Absolute flux distribution (ergs $cm^{-2} sec^{-1} Hz^{-1}$) of the head of the comet P/Swift-Tuttle (1992t) as a function of wave length.

TABLE I

Basic data for comet P/Swift-Tuttle (1992t)

Date	Species	Δ (AU)	r (AU)	g(E-13)	ρ	μ	X
Dec. 2, 1992	CN	1.396	0.975	4.65	1.51 E+4	17.64	0.050
	C_2	1.396	0.975	2.40	1.51 E+4	4.8	0.126
	C_2	1.396	0.975	2.40	1.51 E+4	4.8	0.126
	C_2	1.396	0.975	2.08	1.51 E+4	4.8	0.126
Dec. 3, 1992	CN	1.412	0.972	4.34	1.53 E+3	17.64	0.051
	C_2	1.412	0.972	2.40	1.53 E+3	4.8	0.128
	C_2	1.412	0.972	4.40	1.53 E+3	4.8	0.128
	C_2	1.412	0.972	2.08	1.53 E+3	4.8	0.128
Dec. 7, 1992	CN	1.479	0.963	3.52	1.06 E+4	17.64	0.053
	C_2	1.479	0.963	2.40	1.06 E+4	4.8	0.134
	C_2	1.479	0.963	4.42	1.06 E+4	4.8	0.134
	C_2	1.479	0.963	2.08	1.06 E+4	4.8	0.134
Dec. 8, 1992	CN	1.496	0.961	3.27	1.62 E+4	17.64	0.054
	C_2	1.496	0.961	2.40	1.62 E+4	4.8	0.136
	C_2	1.496	0.961	4.42	1.62 E+4	4.8	0.136
	C_2	1.496	0.961	2.08	1.62 E+4	4.8	0.136

TABLE II

Emission band fluxes,column densities and production rates

Date	Species	Flux(E-10)	M_λ	log(M)	log Q	log Q(solid)
Dec. 2, 1992	CN	1.33	8.93	30.915	26.670	11.49
	C_2	3.83	8.93	30.919	26.888	11.49
	C_2	7.80	8.93	30.969	26.930	11.49
	C_2	4.01	8.93	31.002	26.970	11.49
Dec. 3, 1992	CN	4.29	8.24	30.749	26.493	11.76
	C_2	3.60	8.24	30.907	26.858	11.76
	C_2	6.99	8.24	30.848	26.808	11.76
	C_2	3.16	8.24	30.922	26.879	11.76
Dec. 7, 1992	CN	4.87	8.95	30.897	26.618	11.49
	C_2	3.84	8.95	30.960	26.890	11.49
	C_2	6.16	8.95	30.899	26.830	11.49
	C_2	2.70	8.95	30.896	26.800	11.49
Dec. 8, 1992	CN	6.27	10.41	31.047	26.764	10.92
	C_2	4.28	10.41	31.015	26.940	10.92
	C_2	8.09	10.41	31.026	26.950	10.92
	C_2	4.28	10.41	31.015	26.940	10.92

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. The procedure for determining the column density and production rates are the same as used by Rautela and Sanwal (1992). The column densities were then converted into production rates (Q) through the relation given by A'Hearn and Cowan (1975):

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

where v = velocity of released species, μ = ratio between daughter and parent molecule scale-length, x = ratio between ρ and daughter molecule scale lengths, K_0 and K_1 are modified Bessel fuctions 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 length were taken from Cochran (1985). Bessel functions were calculated using the tables of Abramowitz and Stegun (1964).

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

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

where L is the luminosity at wavelength λ. The production rates and column densities thus calculated are given in Table II.

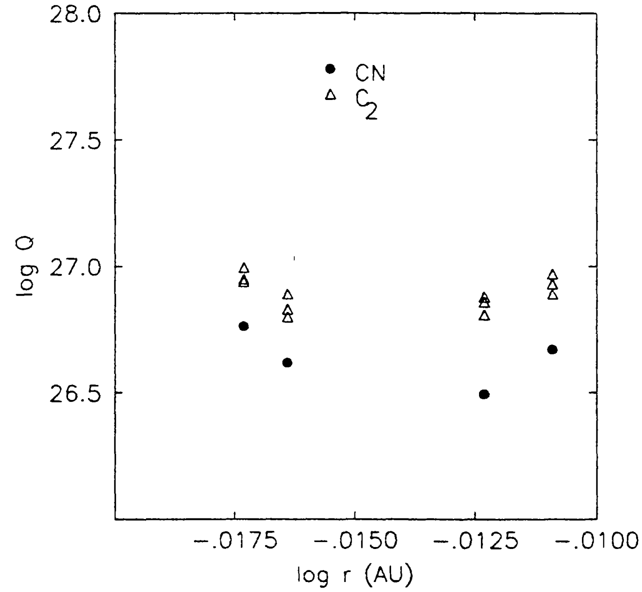

Fig. 2. The production rates of CN and C_2 molecules (s^{-1}) as a function of heliocentric distance (AU).

5. Conclusion

The production rates of CN and C_2 molecular species have been plotted in Figure 2 against the heliocentric distance. The molecular species CN and C_2 show a systematic variation with the heliocentric distance r. The continuum emission on 3rd December is enhanced which shows significant activity in the nucleus of the comet in the form of the emission of more dust particles.

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