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Photometry of comet P/Halley on 1986 March 19

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Abstract. Comet P/Halley was photometrically observed in the coma and tail regions using IHW filters, at a heliocentric distance of 0.99AU, on 1986 March 19. It was found that the maximum flux in the coma occurs for the C_2 molecule, whereas the fluxes in C_3 and CN are almost equal. At a distance of about 5.5×10^4 km from the nucleus across the dust tail no flux was observed in CO^+ and H_2O^+, whereas the fluxes in CN, C_3 and C_2 were found lower as compared to the coma. Assuming Haser model, calculations were done for the production rates of different neutral molecules in the comet.

Key words : filter photometry—comet P/Halley

1. Introduction

Cometary photometry is a good tool for investigating the properties of cometary gas molecules and dust. Recent attempts by IHW (International Halley Watch) for coordinating all the ground based observations by introducing a uniform set of filters have helped us to make a comparison between the data obtained by different observers. We present in this paper the photometric observations of comet P/Halley obtained by us.

2. Observational details and reduction procedures

Observations of P/Halley were made with the 1-m telescope of Vainu Bappu Observatory, Kavalur, with a 24 arcsec aperture (which corresponds to a linear size of about 1.4×10^4 km) using IHW filters, on 1986 March 19. The coma region and a region across the dust tail (henceforth tail) obtained by changing the RA and DEC each by -66.6 arcsec from the centre of the coma (which corresponds to a distance of 5.5×10^4 km) were observed using a photopolarimeter discussed elsewhere (Deshpande *et al.* 1985). The polarimetric results have already been discussed in earlier works (Sen *et al.* 1988, 1989, 1990).

The extinction coefficients were obtained as the mean values of standard stars chosen from those suggested by IHW. The solar type star HD 105590 was observed for photometric calibration (IHW, Photometry and polarimetry net, Circular 1985 November

8). On the basis of the magnitudes of the solar analog in eight different IHW filters, a set of interpolation formulae was set up, to calculate the contribution of continuum in the emission bands (*cf.* IHW Photometry and polarimetry net, Circular 1986 February 3). Since cometary emission is basically due to the scattering of the solar radiation, the expected spectrum of the comet is of solar type on which cometary emissions from CN, C_3, CO^+, C_2 and H_2O^+ are superimposed. The observed extinction corrected magnitudes of the comet at different IHW filters are reduced to the IHW magnitudes using the observed magnitude of the solar-type star HD 105590; and then converted into flux using the flux conversion formulae given in IHW photometry and polarimetry net, Circular 1986 February 3.

3. Results and discussion

The IHW magnitude of the coma and tail regions of P/Halley along with the derived fluxes in different emission bands (CN, C_3, CO^+, C_2 and H_2O^+) are listed in table 1. The calculated flux values have a maximum error of 10%. Figure 1 shows histogram plots of these values. In the coma region, the total flux in C_2 was found to be stronger than CN and C_3; whereas CN and C_3 are almost equal and also within the errors CO^+ and H_2O^+ fluxes were found to be equal, exhibiting weaker emission compared to other emission bands. In the tail, the CO^+ and H_2O^+ emissions are below the detection limit. Table 1 also gives the flux ratio coma/tail for different bands, which shows C_3 is decreasing fastest along the tailward direction and C_2 has decreased slightly faster than CN towards the tail. This is expected, since C_3 has smaller scale length (about 4×10^4 km at 1.0 AU) compared to CN and C_2 (A'Hearn 1982; Delsemme 1975). C_3 is generally found strongly concentrated in the nuclear region and has a larger slope than CN and C_2 (Delsemme 1975). A faster decrease of C_2 than CN can indicate a smaller scale length of C_2 compared to CN. The spatial distribution study of CN by Combi & Delsemme (1980) shows CN has a scale length greater than 3×10^5 km whereas the scale length of C_2 is 1.2×10^5 km (A'Hearn 1982); both the values being at 1.0 AU. The intensity of CO^+ and H_2O^+ vary largely from comet to comet and little spectrophotometry has been done for them (A'Hearn 1982; Delsemmme & Combil 1979).

The number of molecules of each observed species, within a cylinder of radius ρ defined by the diaphragm and extending entirely through the coma can be evaluated by

Table 1. The IHW magnitudes of P/Halley and the derived parameters. Fluxes in continuum are in 10^{-13} ergs cm^{-2} s^{-1} A^{-1} and emission in 10^{-10} ergs cm^{-2} s^{-1}

	Coma			Tail			
wavelength	M_{IHW}	$F(\rho)$	log $M(\rho)$	M_{IHW}	$F(\rho)$	log $M(\rho)$	coma/tail
3650	10.20	6.86		11.00	3.28		
3871	8.15	2.36	29.99	8.40	1.99	29.92	1.19
4060	8.86	2.42	29.44	9.77	1.02	29.07	2.36
4260	9.60	0.07	29.52	10.61			
4845	8.83	14.72		9.87	5.67		
5140	7.49	4.75	30.59	8.23	2.68	30.34	1.77
6840	7.76	13.03		8.82	4.88		
7000	7.69	0.06	27.55	8.82			

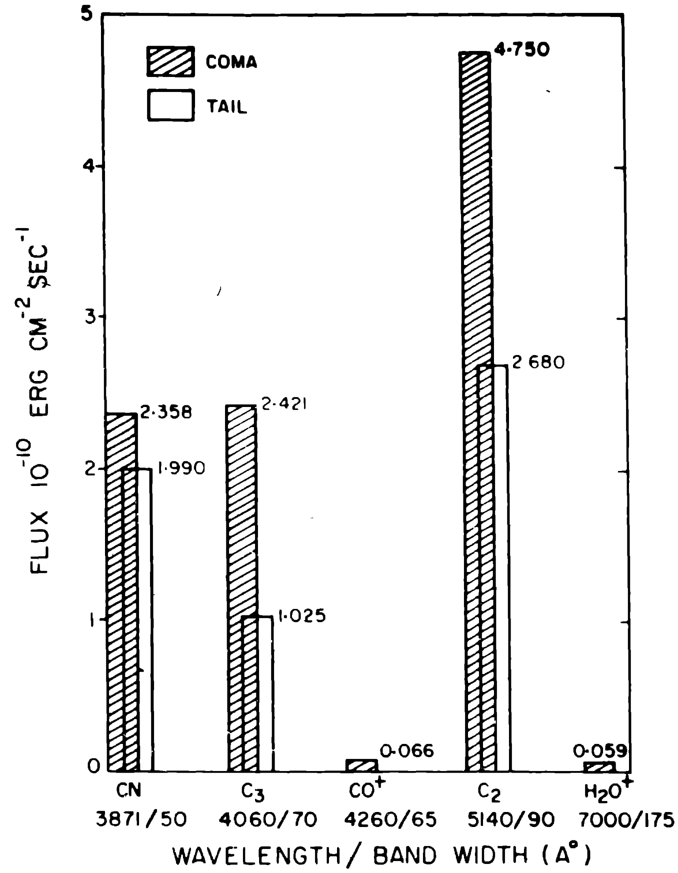

Figure 1. Histogram plots of flux in different emission bands for come and tail regions.

the standard formula (Millis *et al.* 1982).

$$\log M(\rho) = \log F(\rho) + 27.449 + 2 \log (\Delta.r) - \log g, \qquad \ldots(1)$$

where F and g are respectinely the observed flux and fluorescence efficiency per molecule at $r = 1$ AU (both in cgs unit). Following Millis *et al.* (1982) we use $\log g(C_2) = -12.657$ and $\log g(C_3) = -12.000$. Because of Swings effect g(CN) varies significantly with heliocentric radial velocity of the comet. We have found out from figure 1 of Tatum & Gillespie (1977) the approrpiate value of $\log g$(CN) to be -12.360, since at the time of observation the heliocentric radial velocity was 26.42 km s^{-1} (IHW newsletter N 7). From Babu et al. (1989) we take $\log g(CO^+) = -13.441$ and $\log g(H_2O^+) = -11.523$ and using the relation (1) we list the calculated values of $\log M(\rho)$ in table 1. Further by assuming Haser model, the column densities ($M(\rho)$) calculated for the coma can be converted into production rates for the neutral molecules by using the following relation (A'Hearn & Cowan 1975)

$$M(\rho) = Q\, V^{1}\, \rho\, \mu(\mu - 1)^{-1} \left[\int_{x}^{\mu x} K_0(y)dy + (1 - (1/\mu))/x + K_1(\mu x) - K_1(x) \right], \qquad \ldots(2)$$

where V is the velocity of the released species; μ the ratio of daughter and parent molecule scale lengths; x the ratio of ρ and daughter molecule scale length; K_0 and K_1

are the modified Bessel functions of the second kind of order 0 and 1. Assuming $V = 0.58/\sqrt{r}$ (Delsemme 1982; Cochran 1985) and taking the parent and daughter scale length values from Cochran (1985) we calculate the production rates for the neutral molecules CN, C_3 and C_2 (listed in table 2).

Table 2. Log of production rates (Q molecules s^{-1}) of different molecules at the heliocentric distance $r = 0.99$ AU

	CN	C_3	C_2
log Q	27.54	26.68	30.59

Catalano *et al.* (1986) have conducted the pre- and post-perihelion photometry of comet P/Halley for certain heliocentric distances and by plotting the log Q (production rate) values across different log r values, they found the slope of the straight line ($-\alpha$) is 6.2 ± 2.5, 8.3 ± 3.0 and 6.6 ± 2.0 for the molecules CN, C_3 and C_2 respectively. For a comparison, we have plotted the production rate values obtained by us, on the same figure which is reproduced here as figure 2. From this one can comment that within the

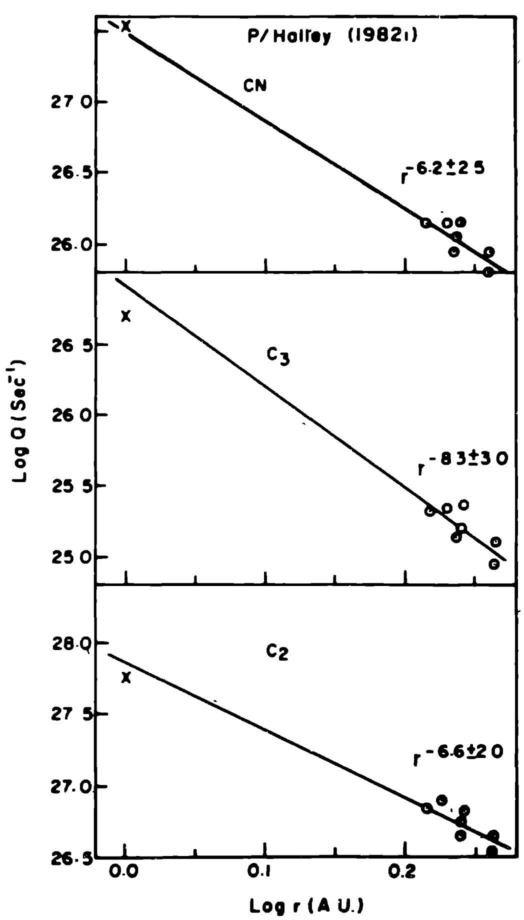

Figure 2. Plot showing log of production rates versus log of heliocentric distance taken from Catalano *et al.* (1987). The points marked by ⊗ represent observations by Catalano *et al.* (1987) whereas points marked by × represent our observations.

errors, our production rate values follow the same trend of heliocentric distance dependence as obtained by Catalano *et al.* (1986).

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