MASS LOSS RATES OF THREE COMETS

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ABSTRACT. Emission features of C_2, C_3, CN, and dust in Comets Thiele (1985m), Hartley-Good (1985l), and Giacobini-Zinner (1984e) have been analyzed and their mass loss rates of about 0.5, 1.1, and 0.8 Mg s^{-1} have been determined.

Photoelectric photometry of Comets Thiele (1985m), Hartley-Good (1985l) and Giacobini-Zinner (1984e) in the system of standard IHW filters was performed at the 90-cm telescope of Lena University by Stecklum et al. (1987). They reported magnitude measurements at 387.1, 406.0, and 514.0 nm corresponding to CN, C_3, and C_2 emissions and at 365.0 and 484.5 nm continuum in CU and CB filters. The continuum brightness m_{em}^{cont} in the molecular emission filters can be interpolated from "short-" and "long-wavelength" filter magnitudes m(CU) and m(CB)

$$\begin{aligned} m_{em}^{cont}\ (387.1\ \text{nm}) &= 0.8151\ m(CU) + 0.1849\ m(CB) + 0.494, \\ m_{em}^{cont}\ (514.0\ \text{nm}) &= -0.2469\ m(CU) + 1.2469\ m(CB) + 0.244, \\ m_{em}^{cont}\ (406.0\ \text{nm}) &= 0.6569\ m(CU) + 0.3431\ m(CB) + 0.088. \end{aligned} \tag{1}$$

The filter magnitudes m_{em} at 514.0, 406.0 and 387.1 nm were converted into emission band fluxes F_{em} [erg $cm^{-2}s^{-1}$] using the reduction formula

$$F_{em}(\lambda) = (D + E \cdot T) \cdot \left(10^{-0.4 m_{em}} - 10^{-0.4 m_{em}^{cont}}\right). \tag{2}$$

Here T denotes the filter temperature in °C assumed to be 0, $D = 5.38 \cdot 10^{-7}$, $1.38 \cdot 10^{-6}$, and $6.81 \cdot 10^{-7}$ for CN, C_3, and C_2, respectively; corresponding values of E are $-0.021 \cdot 10^{-7}$, $0.003 \cdot 10^{-6}$, and 0.0. For the column densities of CN, C_2, and C_3, we took g-factors at $r = 1$ AU from Tatum (1984), Landaberry et el. (1991), and de Almeida et al. (1989) combined with an r^{-2} power law. The magnitude measurements of Stecklum et al. (1987) at wavelength 484.5 nm for scattering by coma dust were converted into continuum fluxes by Singh et al. (1991).

Comet Hartley-Good (1985l): Since OH is a photodissociation product of H_2O, the Tacconi-Garman et al. (1990) vector model OH production rates correspond to an average H_2O production rate $Q(H_2O) \approx 3.2 \cdot 10^{28}\ s^{-1}$ when interpolated to $r = 1$ AU. However, since the vector model gives production rates about 50% higher than the Haser model (Schleicher et al., 1987), the Haser model $Q(H_2O) \approx 2.1 \cdot 10^{28}\ s^{-1}$ at $r = 1$ AU, which is in agreement with $2.8 \cdot 10^{28}\ s^{-1}$ derived by Singh et al. (1991) considering Hartley-Good as a "normal" comet [i.e. $(Q(C_2)/Q(CN) \approx 1.4]$. Assuming a gas mixture of 90% H_2O and 10% other gases of mean molecular weight 44 amu, we find that early in November, 1985, the comet was loosing $\sim 9.8 \cdot 10^5$ g s^{-1} gas and $\sim 1.4 \cdot 10^5$ g s^{-1} dust, for a total mass loss of about 1.1 Mg s^{-1} at $r = 1$ AU preperihelion.

Comet Giacobini-Zinner (1984e): $Q(C_2)/Q(CN) \approx 0.3$ on August 14 and 29, 1985. In this comet C_2 is depleted by a factor of 5 relative to CN [$Q(C_2)/Q(CN) \approx 1.5$ in "normal" comets (Cochran, 1987)]. For Comet Giacobini-Zinner, $Q(CN)/Q(H_2O) \approx 1.8 \cdot 10^{-3}$ (Landaberry et al., 1991). Thus the CN production rate on August 14, 1985, assuming an expansion velocity of 1 km s^{-1}, yields a Haser model $Q(H_2O) \approx 4.5 \cdot 10^{28}\ s^{-1}$ at $r = 1.08$ AU. Tacconi-Garman et al. (1990) determined $Q(OH) \approx 5.15 \cdot 10^{28}\ s^{-1}$ during August 24 to 26, 1985, ($r \approx 1.04$ AU) using the vector model, which corresponds to a Haser model $Q(H_2O) \approx 4 \cdot 10^{28}\ s^{-1}$ at $r \approx 1.04$ AU, in agreement with our value. Landaberry et al. (1991) derived $Q(H_2O) \approx 1.6 \cdot 10^{28}\ s^{-1}$. Since H_2O is a major constituent of the coma, the gas production rate is $\sim 4.7 \cdot 10^5$ g s^{-1} at r

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= 1.08 AU. The dust production rate on August 14, 1985, is ~ 3.5 · 10^5 g s^{-1} (Singh et al., 1991). Thus the comet was loosing a total mass of ~ 0.8 Mg s^{-1} at r = 1.08 AU before perihelion.

Comet Thiele (1985m): Tacconi-Garman et al. (1990) determined a Q(OH) ≈ 1.37 · 10^{28} s^{-1} from the November 12 and 14 to 18, 1985, observations (r ≈ 1.41 AU). This Q(OH) corresponds to a Haser model Q(H_2O) ≈ 3.2 · 10^{28} s^{-1} at r = 1 AU when extrapolated by an r^{-2} power law. This is a factor of ~ 2 lower than the H_2O production rate (6 · 10^{28} s^{-1}) derived by Singh et al. (1991) at r = 1 AU, which was derived from a peak OH production rate of 3 · 10^{28} s^{-1} (December 9, 1985, r = 1.3 AU; Gérard et al., 1987) and is an upper limit. On November 4, 1985 Q(C_2)/Q(CN) ≈ 1.1 and shows that the comet belongs to the family of "normal" comets (Cochran, 1987). In a "normal" comet Q(CN)/Q(H_2O) ≈ 1.33 · 10^{-3} (Spinrad, 1987; Newburn and Spinrad, 1989). The November 4, 1985, observations of Comet Thiele by Stecklum et al. (1987) show a mean Haser model Q(CN) ≈ 1.6 · 10^{25} s^{-1} at r = 1.48 AU and hence the extrapolated Haser model Q(H_2O) ≈ 1.2 · 10^{28} s^{-1} at r = 1.48 AU. If Q(H_2O) follows an r^{-2} power law, then the Haser model Q(H_2O) ≈ 2.6 · 10^{28} s^{-1} at r = 1 AU. Since the vector model yields production rates about 50% higher than the Haser model, we consider our derived water production rate of 3.9 · 10^{28} s^{-1} at r = 1 AU in good agreement with the extrapolated value of 3.2 · 10^{28} s^{-1} obtained from the Tacconi - Garman et al. (1990) observations. Following the analyses of the above comets, our extrapolated Haser model H_2O production rate yields a gas production rate of ~ 4.1 · 10^5 g s^{-1} at r ≈ 1.48 AU. The dust production rate on November 4, 1985, was ~ 7.8 · 10^4 g s^{-1} (Singh et al., 1991). Thus the comet was loosing a mass of ~ 0.5 Mg s^{-1} at r= 1.48 AU.

TABLE 1. CN, C_2, & C_3 FLUXES & COLUMN DENSITIES

Date 1985	Time (UT)	r (AU)	Δ (AU)	(Species)	Flux (erg cm^{-2} s^{-1})	Col. density (cm^{-2})
			Comet Hartley-Good (1985l)			
Nov. 3	18.54	1.00	0.73	CN	4.77(-11)	7.966(10)
				C_2	4.25(-11)	7.916(10)
				C_3	1.42(-11)	3.720(10)
Nov. 4	18.23	0.98	0.74	CN	6.07(-11)	9.604(10)
				C_2	5.45(-11)	9.747(10)
				C_3	2.03(-11)	5.110(10)
			Comet Thiele (1985m)			
Nov. 4	00.36	1.48	0.528	CN	6.93(-12)	2.777(10)
				C_2	3.89(-12)	1.587(10)
				C_3	2.93(-12)	1.681(10)
	19.37			CN	4.22(-12)	1.691(10)
				C_2	4.11(-12)	1.677(10)
				C_3	4.04(-12)	2.317(10)
	19.48			CN	6.39(-12)	2.561(10)
				C_2	3.19(-12)	1.302(10)
				C_3	4.03(-12)	2.312(10)
			Comet Giacobini-Zinner (1984e)			
Aug14	23.25	1.08	0.53	CN	8.66(-11)	1.741(11)
				C_2	1.51(-11)	3.281(10)
Aug29	02.16	1.03	0.48	CN	2.66(-11)	6.143(10)
				C_2	5.33(-12)	1.053(10)
				C_3	6.05(-13)	1.481(09)

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