COMET P/HALLEY 1910, 1986: An Objective-Prism Study.

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Comets are the most distant voyagers of the solar system, sampling regions that are essentially "interstellar" in nature. Unlike the larger planets they have undergone only little,if any, metamorphosis over the history of the solar system, and can therefore provide information on the physical and chemical state of the primordial solar nebula. The tiny cometary nucleus, the dirty snowball of frozen gases mixed with dust, becomes active following its interaction with the solar radiation field and wind. The results are the extended gaseous coma and the long double tail (plasma & dust), features that kept humankind fascinated throughout the ages. The physical processes involved are: sublimation, photo excitation (fluorescent scattering), photo dissociation, photo ionization, dissociative recombination, etc... The observed cometary spectrum is a superposition of molecular emission bands, atomic emission lines, and reflected (by dust) solar continuum.

V. M. Slipher of the Lowell Obs. collected a large amount of spectroscopic data during the 1910 apparition of Halley's comet. We selected 3 of his post-perihelion objective-prism plates (Table 1), digitized them and subjected them to modern digital data reduction procedures. Some of the important steps in our analysis where: 1) Density to intensity conversion for which we used 1910 slit spectra of Fe-arc lamp on similar plates (Sigma) and derived an "average" characteristic curve; 2) Flux calibration using the fact that during the period June 2-7 1910 P/Halley was very close (angular distance) to the bright star Alpha Sex (A0III, V=4.49), and the spectra of both star and comet were recorded on the same plates. We assumed that the flux distribution of Alpha Sex is similar to that of the standard star 58 Aql (A0III) and derived a sensitivity curve for the system; 3) Atmospheric extinction using the standard curve for the Lowell Obs.; 4) Solar continuum subtraction using the standard solar spectrun binned to our spectral resolution.

In Fig. 1 we present an example of a flux-calibrated spectrum of the coma (integrated over 87,000km) before the subtraction of solar continuum. All the "classical" features, e.g. molecular emission bands, are present and display the typical band head structure. In objective-prism spectroscopy (no aperture) the observed emission regions are considerably larger than the projected scale lengths for photo dissociation of the various species. If we assume that the coma is optically thin, the total number of emitting molecules (N) is given by:

$$N = \frac{4\pi F}{g} \Delta^2 r^2$$

where F [ergs/cm^2/sec] is the observed flux in a particular band, Δ [AU] is the distance comet - earth, r [AU] is the distance comet - sun, and g [ergs/molecule/sec] is the fluorescence efficiency at 1 AU. Traditionally, instead of the coma abundance for a given species, what is given is the production rate (Q) of the species, which under steady state condition is related to N by:

$$Q = \frac{N}{\tau}$$

where τ [sec] is the lifetime of the species. Our results for both N and Q are presented in Table 2. These results are, to our knowledge, the first quantitative physical values from the 1910 apparition of comet P/Halley. It is yet too early to compare the 1910 results with new 1986 results. However, we present here some preliminary results.

Our 1986 objective-prism plates (Fig. 2) were obtained on January 12.13 and 13.13 1986 using the Burrell Schmidt (Kitt Peak) with the 10° prism. We used IIIaJ and IIIaF plates with spectral coverage of 3700Å to 5000Å and 3700Å to 7000Å, respectively. We are still in the midst of the data reduction and analysis.

Table 1. The 1910 Data

Plates	:	Sigma		
Plate Scale	:	1050"/mm or 21"/pix		
Spectral range	:	3700Å - 4950Å		
Linear dispersion	:	1.237 Å/pix at λ3885 and 2.945 Å/pix at λ4735		
Dates (UT)	:	June 2.25,	3.264,	6.267
Delta (AU)	:	0.53	0.57	0.685
r (AU)	:	1.062	1.07	1.12

Table 2. The 1910 Results

Emission bands	CN(λ3883)	C_2(λ4737)	C_3(λ4050)	CH(λ4315)
g [ergs/mole/sec]	3.23(-13)	2.59(-13)	1.03(-13)	9.2 (-13)
Column Density $_2$ [molecules/m^2]	1.3 (15)	0.8 (15)	5.5 (13)	1.0 (13)
N [molecules]	3 (32)	2 (32)	2.5 (30)	4.5 (29)
τ [10^5 sec]	2.1-6.3	0.7-2.1	0.35-1.05	0.07-0.21
Q [mole/sec]	0.5-1.4(27)	0.9-2.8(27)	2.4-7.1(25)	2.1-6.4(25)

Note: exponents of ten are in parenthesis

Fig. 2. Objective-prism spectrum of comet P/Halley 1986

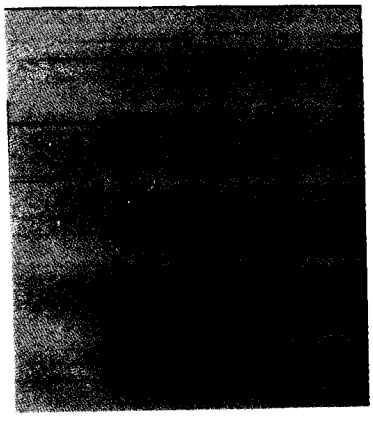

Fig. 1. Flux-calibrated coma spectrum of comet P/Halley 1910