SEARCH FOR HYDROGEN ATOMS AND THE NOBLE GAS ABUNDANCES IN THE HEAD OF COMET SCHWASSMANN - WACHMANN 1 (1974 II) FROM VOYAGER 2 UVS SPECTRA

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ABSTRACT

Comet P/Schwassmann-Wachmann 1 (1974 II) has been observed during three weeks in 1980 in the 500-1700 Å wavelength interval using the Ultraviolet Spectrometer of the Voyager 2 spacecraft. No Lyman-alpha emission of hydrogen atoms has been positively deteced. However, the variation of the measured HI Lyman-alpha emission of the interplanetary medium can be satisfactorily expalined if a weak "cometary" component were present during the first part of the observing run. If H-atoms were present in the head of the comet, the production of their parents far exceeded $10^{30}s^{-1}$, making this comet an object whose size is an order of magnitude larger than of any other known comet. Upper limits on the productions of helium. neon, and argon have also been deduced.

INTRODUCTION

Comet P/Schwassmann-Wachmann 1 (1974 II), hereafter P/SW1, has been observed at almost all its oppositions since its discovery in 1927. The orbital characteristics of this comet and an ephemeris may be found in the works of Herget (1961, 1968). Various reviews of past observations are given by Vsekhsvyatskii (1964), Richter (1964), Hughes (1975) and Whipple (1980).

Most observations report that the "normal" state of the comet is a quiescent one during which the comet is stellar in appearance and has a visual magnitude in the 17 to 19 range. Unpredictable outbursts yielding brightness increases of 6-8 magnitudes occur during periods of time which can extend over many weeks (as illustrated by the oppositions of the winters of 1976, 1977 and

1981 which were especially well studied - see the corresponding I.A.U. circulars and Hurahata, 1982). The typical development of the coma during an outburst is described by Richter (1964) and can be seen in Roemer's photographs (1958, 1963). Whipple (1980) has used the numerous observations of the expansion of dust halos to determine the rotation period of the nucleus of about 5 days.

There are few spectroscopic studies of this comet, mainly because of its faintness. Earlier observations by Mayall (1941), Herbig (cited by Jeffers 1946), and Walker (1959) exhibit only solar features, while recent ones (Cochran, Barker and Cochran, 1980) succeeded in detecting CO^+ bands near 4000 Å. While it is evident that the dust is dragged away from the nucleus by a gaseous component, the nature of this gas is still unknown. The above-mentioned observations strongly support the hypothesis of the presence of CO in the nucleus of comet P/SW1. However, the nondetection of other emissions does not allow us to conclude on the absence of other species. Since the comet is situated very far from the Sun those species are likely to form very extended comae with low surface brightnesses.

Since an ultraviolet spectrum of P/SW1 is expected to provide significant information regarding the chemical nature of that comet, we have carried out observations of come P/SW1 with the Ultraviolet Spectrometer of the Voyager 2 spacecraft while it was cruising between Jupiter and Saturn. The following observations show that is is possible that comet P/SW1 produces a parent molecules which yields atomic hydrogen, in addition to the parents of the previously observed CO^+ ions. Furthermore, the analysis of the data also yields upper limits of the production of the principal rare gases.

II. OBSERVATIONS

The Ultraviolet Spectrometers (UVS) of teh Voyager spacecraft have been designed to study the composition of the atmospheres of the outer planets and their satellites. A detailed description of the UVS is given in Broadfoot et al. (1977). Only those details relevant to the present observations are given here. The Voyager 2

UVS is an objective grating spectrometer covering the spactral range of 510-1690 Å in 126 contiguous channels. The field of view (FOV) has a full width at half maximum (FWHM) of 0.1° in the dispersion direction and a length of 0.87°. Spectral and spatial resolutions are not independent. A monochromatic source which fills the FOV produces a triangular intensity distribution with a FWHM of 0.1°, which corresponds to a 33.1 Å spectral width. A monochromatic point source produces a linewidth of 25 Å. The detector channels have a width of 0.028° or 9.26 Å.

Comet P/SW1 was observed during two periods, 18-21 January, 1980 (Period 1) and 25 January - 4 February 1980 (Period 2), while its geocentric equatorial coordinates were $\alpha=135^{\circ}$ and $\delta=+17.8^{\circ}$. The Sun-comet distance was 6.18 A.U. The Voyager 2 spacecraft was 4.41×10^{8} km (2.95 A.U.) from the comet, 9.2×10^{8} km (6.13 A.U.) from the Sun and at the ecliptic longitude of 156° */Fig. 1/*.

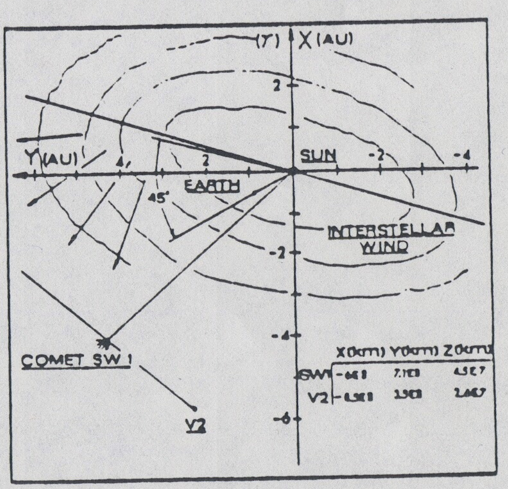


Fig. 1. Positions of Earth, Comet P/SW1 and the V2 spacecraft in a heliocentric ecliptic rectangular frame of reference around January 20, 1980. Both P/SW1 and V2 can be considered as motionless during the observation period. The sketch of the density distribution of interplanetary hydrogen atoms is for illustration only and do not correspond to any precise model or measurements.

The center of the slit of the spectrometer was positioned on the comet at the beginning of each of the two periods. During these periods, small motions of the viewing direction with respect to the target direction occured due to the attitude control motions of the spacecraft and the proper motions of both the spacecraft and the comet. We shall consider only those spectra obtained by a spatial binning around the comet position in the direction perpendicular to the length of the slit. That direction was indeed almost parallel to the eclipcit plane. 906 and 2960 spectra were obtained during the abovementioned two periods respectively, with a total integration time of 206 hours (or 8.58 days).

The procedure used to reduce the data is presented in detail in Broadfoot et al. (1981). It consists mainly of the subraction of noise induced by the gamma rays from the radioisotope thermoelectric generators on board the spacecraft, followed by the correction for scattering within the instrument. *Figure 2a* represents a typical spectrum recorded on January 18, 1980 (averaged over 70 spectra corresponding to a total integration time of 3.7 hours). *Figure 2b* represents the noise spectrum which has been subtracted from each individual spectrum. Intensities in all our spectra are given in counts per 192s, the integration time of an elementary spectrum, because integration periods vary. Absolute intensities will be given later, using the absolute calibration curve found in Broadfoot et al. (1981). In *Figure 2a*, only the strong H I Lyman alpha and He I 548 Å emissions can be identified. *Figure 3a* shows the spectrum obtained by summing all the data recorded during Period 1. On this expanded scale, the H I Lyman beta (1026 Å) interplanetary emission (Sandel, Shemansky and Broadfoot, 1978) is easily recognized. After subtraction of the noise spec-

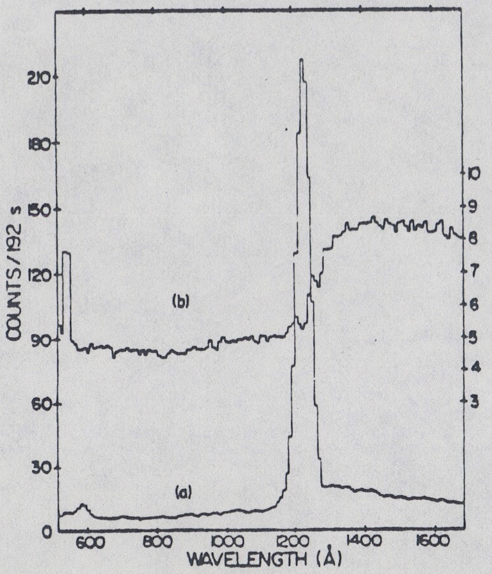
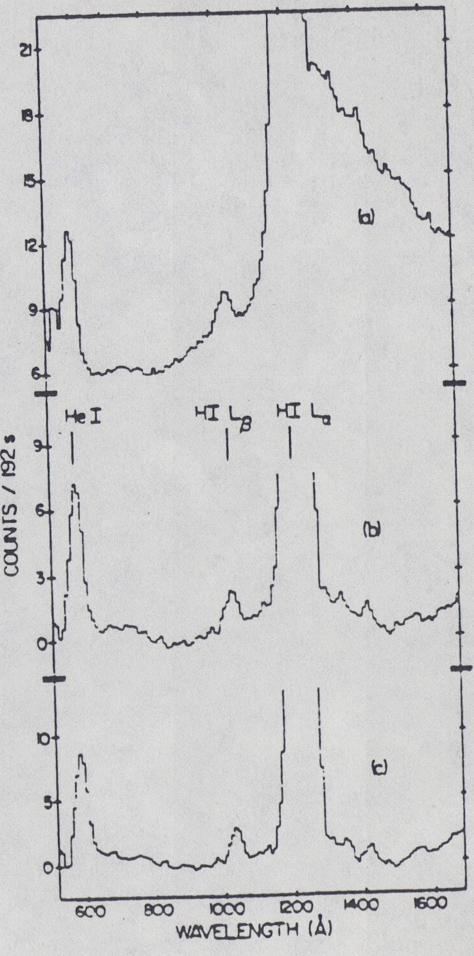


Fig. 2. a/ Raw spectrum obtained by averaging 70 spectra recorded on January 18, 1980 within ±0.3° from the comet position. The interplanetary emission is simultaneously recorded /scale on the left/.
b/ Background spectrum induced by gamma rays /scale on the right/.

trum of *Figure 2b* from *Figure 3a*, a residual signal of approximately 1 count/192 s at all wavelengths is due to internal scattering of the intense HI 1216 Å line. *Figure 3b* shows the spectrum which results from removal of this instrumental effect. In order to test the validity of our reduction procedure and estimate the significance of small features of our spectra, we have reduced a pure interplanetary spectrum taken a few months earlier in the direction of the north galactic pole using the same technique. The result is displayed in *Figure 3c*: the high similarity between spectra *3b* and *3c* allows use to say that not features other than those previously mentioned are present in both spectra *3b* and *3c*. In other words, if cometary emissions are present in

Fig. 3. /left/

- *a/ Raw spectrum obtained by averaging 903 spectra recorded during period 1 /January 18-21, 1980/ within ± 0.3° from the comet position. The integration time is 48.3h.*
- *b/ Some as a/ after subtraction of the background and removal of the instrumental scattering. Error bar values are indicated in the text.*
- *c/ Spectrum of the interplanetary medium viewed in the direction of the north galactic pole. The integration time is 63.3h.*



our spectra, they are superimpsed on the HI and HeI interplanetary lines. The standard deviations for individual channels in *Figure 3b* are 0.7 and 2.1 counts/192 s at $\lambda=584$ Å and $\lambda=1216$ Å, and about 0.5 counts/192 s at all other wavelengths. Since the instrumental response to an extended monochromatic line is 33 Å wide (FWHM), the intensities of the lines were obtained by summing 8 contiguous channels and the above standard deviations were reduced by a factor of about 2.5.

III. DATA ANALYSIS

All our spectra show the three features, HeI, HI Ly α and HI Ly β, present in *Figure 3b* and *3c*. We have grouped the date in 14 periods lasting an average of 12 hours each during which the comet was observed almost continuously. *Figure 4* represents the

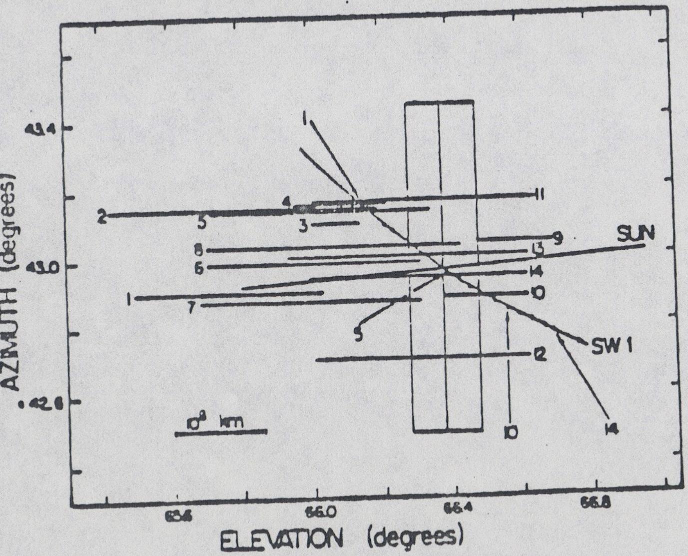


Figure 4./right/. Trajectory of comet P/SW1 in the Voyager 2 scan platform coordinate system during the observation. The straight lines indicate the range of position of the slit center /whose projection on the sky is shown for January 26/ during the 14 periods of observation. Azimuth and elevation are a set of spherical angles orthogonal to the UVS slit.

trajectory of the comet in the azimuth-elevation spacecraft frame of reference, as well as the projected size of the slit and the position of its center during these 14 periods. The comet nucleus was not within the slit at all times: it was within the slit during 60%, 10%, 50% and 20% of periods 1-4, 5-8, 9-11 and 12-14 respectively. The comet was within 0.3^{o} from the center of the slit during approximately 90% of the time. Departures from the average azimuth positions in *Figure 4* did not exceed 0.1^{o}. Note that, as seen from the spacecraft, 0.1^{o} corresponded to 7×10^{5} km at the comet position.

The observed Lyman alpha intensities lie in the 850-950 Rayleighs range, as is indicated in *Figure 5*. The dotted line in *Figure 5* represents the solar Lyman alpha flux measured at the

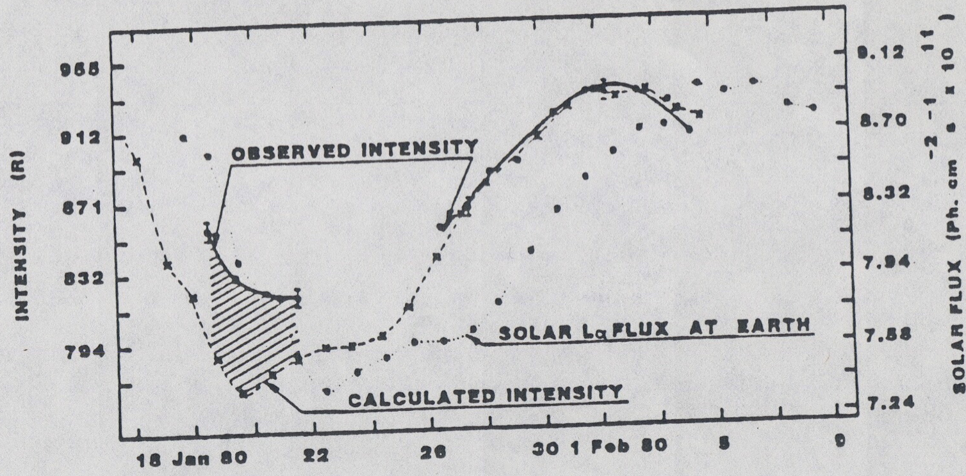


Fig. 5. *Lyman alpha intensity in Rayleighs measured by the UVS /solid circles/. The dotted line represents the solar Lyman alpha flux measured at the Earth /in photons cm^{-2} s^{-1}/ by Hinteregger while the broken line represents the average solar flux seen by the interplanetary hydrogen atoms assuming a lag time of about 3 days /see text for details/. Normalization in done around January 27, when the instrument was looking the farther away from the comet position.*

Earth by Hinteregger (1980, personal communications). Since the Earth was very favorably placed, i.e., very nearly on the Sun-comet line, one would expect to observe a direct proportionality between these two quantities if the H-atoms were not distribued over too long a portion of the line of sight and/or if the optical depth for the solar Lyman alpha photons scattered by the interplanetary atoms was low. Such a correlation is not observed. However, some common patterns (compare the full and dotted lines of *Fig. 5*) can be easily recognized and the observed curve, after January 27, 1980, can be explained if the measured solar flux curve is advanced by about three days. The dashed line in *Figure 5* represents the result of such a displacement, taking into account the rotation of the Sun and the orbital motion of the Earth - individual points are displaced by 2.5 to 3.5 days - as if the solar Lyman alpha emission were due to a single emissive area on the Sun's surface.

Physically, this operation means that the interplanetary H-atoms respond to the solar flux emitted by the Sun in a direction - 45° from the Sun-Earth vector: this direction almost exactly coincides (by chance) with the outgoing direction of the interstellar wind /*Figure 1*/. Since this direction does not intersect the V2-P/SW1 line of sight before about 15 A.U., one is forced to conclude that either the observed H-atoms are situated very far from the Voyager 2 spacecraft or they are much closer and lit indirectly as sketched in *Fig. 1*.

If multiple scattering from a large hydrogen cloud were present, it would tend to reduce the amplitude of the variations of the intensity seen by the V2 instrument as compared to what is observed at Earth. However, since the observed and predicted curves of *Figure 5* match each other after January 26, this effect should be small. As a matter of fact, models of the interplanetary hydrogen do not predict an accumulation of H-atoms behind the Sun when the radiation pressure on the hydrogen atoms overcomes the solar gravity (Holtzer, 1977).

Figure 5 shows that the observed data and the prediction based on the above-mentioned technique do not match between January 18 and January 21, 1980. We attribute this disagreement tentatively to the presence of hydrogen atoms produced by comet P/SW1. *Figure 5* shows that the cometary emission would have decreased in 3 days from about 60 R to 30 R. Uncertainties from counting statistics are of the order of ± 10 R. Because the solar output is slowly varying and the solar lag angle corresponds to a 3 day rotation angle, one cannot expect the fit between the observed and the measured curves to be perfect. An additional 10 to 15 R uncertainty seem reasonable if one compares these two curves after January 26. Thus, the intensity decrease of the cometary emission between January 18 and 21 might not be real, or be different from the one observed. However, the intensity decrease observed between January 18 and January 26 is real. In order to check that the observed fit after January 26 was not fortuitous, we have analyzed previous observations of the intarplanetary medium obtained by the UVS instrument in a constant direction. Using Hinteregger's solar fluxes we obtained the same "lag" effect. However, the lag time was about 14 days, a value much too large to assume the solar flux to be constant over this time period. Despite these unfavorable geometrical conditions, the departures between the observed and predicted curves did not exceed 8-10%. This is an indication that the fit would have been much better if the lag angle were smaller.

Consider now the case that a strongly active area of the Sun would increase the interplanetary Lyman alpha signal between 18 and 21 January, and then be inactive by the time it was observable from the Earth. This would not be possible for two reasons. First, the fraction of the surface of the Sun which is observed from the Earth overlaps with the one which emits the photons scattered by the observed interplanetary H-atoms, and second, the duration of this phenomenon - at least 4 days - exceeds the above-mentioned lag time of 3 days. Consequently this phenomenon, if real, should have been observed from the Earth, which is not the case.

We attempted to spatially bin the spectra; by reducing the number of spectra we averaged, we increased the statistical uncertainties. At the 1 σ level, we observed a higher intensity at the comet location as compared to the surrounding background only on January 18. Owing to the large value of the width of the slit and the probable large extension of the emitting cloud, it is not surprising that a clearer result was not obtained. An order of magnitude estimate of the cometary emission will be given in the next section. A very small diaphragm and long exposure times would have been necessary to detect a weak Ly α maximum at the comet position.

The Ly β emission has an average intensity of 1.44 ± 0.28 R. Since it is superimposed on the blue wing of the Ly α line in the instrument, most of the dispersion of the measured individual values is explained by statistical uncertainty in the background substraction rather than in variation of the solar Ly β flux. No concerning the presence of a Ly β component of cometary origin can be drawn from these measurements. The theoretical ratio of the Ly α to the Ly β emission is about 410 if we assume that the solar fluxes have a ratio of 80 and that the linewidths of the two corresponding solar lines are respectively 0.8 and 0.5 Å. (Lemaire et al., 1978). The ratio mesured by Sandel, Shemansky, and Broadfoot (1978) was 360 ± 54. In the present observations this ratio is twice as high (600 ± 180). The absorption of the Ly α emission along the line of sight can only decrease this ratio. No conclusion can be drawn concerning the discrepancy between the observed and calculated values of this ratio; the theoretical ratio we mentioned assumes that solar lines have a square and that no Doppler effect modifies its value. As a matter of fact, the observing geometry was very different in our observations than in the Sandal et al., (1978) case.

Our measurements of the HeI 584 Å emission are presented in *Figure 6*. The agreement between our observations and Hinteregger's solar He 584 Å flux measurements (1980, private communication) is poor despite higher error bars. A nearly perfect fit is obtained if a translation of about -2 days on the time scale is carried out. The interpretation is straightforward since the interplanetary medium is optically thin at the He 584 Å wavelength: the He atoms on the line of sight respond to the solar flux emitted by the Sun about 30° from the Sun-Earth direction. This can be interpreted by the fact that the He atoms are not close to the instrument, they are probably dispersed over 10 A.U. or more. There is no reason to expect the lag angles observed at 584 Å and 1216 Å to be similar since the solar photons at those wavelengths are not necessary emitted by the same areas on the solar

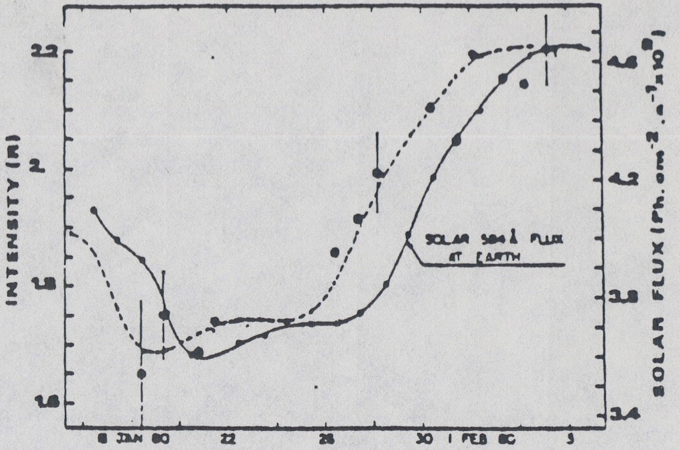


Fig. 6. UVS measurements of the HeI 584 Å intensity are represented by the solid circles. Hinteregger's HeI 584 Å solar flux measurements at Earth are indicated by the full line. A displacement of about 2 days /dashed line/ produces a good fit to the data.

surface and since He and H atoms have different spatial distributions. In addition, the interplanetary medium is optically thin at 584 Å (Weller and Meier, 1974) while some optical depth effects might occur at 1216 Å such as the radiative transport of the solar photons modifying the effective excitation rate (Keller and Thomas, 1979; Keller, Richter and Thomas, 1981). We conclude that no detectable cometary He 584 Å emission is present in our data.

IV. INTERPRETATION OF THE RESULTS

To convert the observed cometary intensities into column densities averaged over the projected area corresponding to the instrumental slit, we assume that the cometary H-atoms are principally excited by photons coming directly from the Sun. This assumption is justified by the fact that the comet is relatively close" to the Sun (6.18 A.U.), and that the optical depth at 1212 Å between the comet and ths Sun for the present geometry is about 0.2 (Bertaux et al., 1980).

If the solar flux measurements of Mount, Rottman and Timothy (1980) were used instead of Hinteregger's values, the estamined intensity of 60 R would result in column densities (and, thus, production rates of H-atoms by the comet) lower by approximately 60%.

We have computed the density distrubution of the hydrogen atoms using the vectorial model developed by Festou (1981). Due to the fact that the comet was at 6.18 A.U. from the Sun, we have assumed that only hydrogen atoms produced by the photodissociation of molecules coming directly from the nucleus could have contributed to the observed emission. An eventual second component produced by the photodissociation of a cometary radical would produce a very extended cloud having a uniform and low column density distribution (Festou et al., 1979).

The parameters of this model are the velocities and lifetimes of both the parent molecules and the hydrogen atoms. The production rate of the parent is a scaling factor if we assume that a steady state is reached. Isotropic emission of the parent is assumed. Conservatively, we assumed that the velocity of the parent molecules was 1 km s^{-1} and that the lifetime of the hydrogen atoms was infinite (actually 3 weeks at 1 A.U.). We are then left with two parameters: the lifetime τ_p of the parent molecules and the velocity V_H of the hydrogen atoms. We have varied these parameters over a large range of values: τ_p (at 1 A.U.) of 2×10^4 to 2×10^5s and V_H of 5 to 20 km s^{-1}, Irrespective of the adopted set of values for these parameters, all integrated density profiles are nearly alike up to distances of few 10^6 kilometers from the nucleus, an effect which can be attributed to the large heliocentric distance of the comet as well as to the vectorial combination of the velocity vectors of the cometary particles. These column density profiles only differ by their absolute values. When the effect of the instrumental field of view is taken into account, the influence of the position of the comet with respect to the center of the slit can be explored. We find that the average column density does not vary (or varies only slightly) when the offset is of the order of $\pm$ 0.15° (or $\pm$, 10^6 km). An offset of 0.1° results in a decrease of the calculated intensity by a factor of 2, a rate of decrease which is not detectable by the instrument since the signal to noise ratio then becomes smaller than unity.

Under these circumstances, our data permit us only to derive an order of magnitude production rate of the (unknown) parent of the hydrogen atoms. Assuming a steady production of parents having a lifetime τ_p of 10^5 s (at 1 A.U.), a velocity of the hydrogen atoms of 10 km s^{-1}, the production rate of these parent molecules required to explain our data is in the 3×10^{29} s^{-1} to 6×10^{29} s^{-1} range. These figures vary almost exactly as the inverse of the lifetime of the parent and as the inverse of the velocity of the hydrogen atoms. A lifetime of the parent of 2×10^4 s (at 1 A.U.) and a velocity of the hydrogen atoms of 5 km s^{-1} would lead to a range of 1 to 2×10^{29} s^{-1}, while values as high as (6 to 12)$\times10^{29} s^{-1}$ would be reached with the combination, $\tau_p = 2\times10^5$s and V_H=20 km s^{-1}.

The decrease of the observed intensity with time during periods 1 to 4 is real and not due to the offset of the slit as the maximum intensity (January 18) was measured while the comet was measured while the comet was at less than 0.1° from the slit center during only 30% of the time as compared to a total of 60% for the sum of those periods. On the other hand, no emission was detected after January 26, irrespective of the value of this offset. This is then an indication that an outburst took place on January 18 or before. Very few visual observations are available to support this conclusion. However, Bortle (1980a) indicates that the coma (magnitude 11.6) was extended over 2.3 arc minutes on January 21 and 22, 1980. Larson (private communication) observed m ~ 16 on January 23 within a 30 arc second diaphragm, while the comet was much fainter and more diffuse on February 4, 5 and 6 (Bortle, 1980b). Ohter observations reported in this last reference seem to indicate that an outburst took place between January 1 and 21 while another one was observed around mid February.

We have therefore used the same model to investigate the outburst parameters which could fit our observations. Outbursts were defined by the time of their beginning, their duration and their magnitude measured by an assumed constant production rate ($\tau_p = 10^5$s at 1 A.U.; V_H = 10 km s^{-1}). We found that an outburst lasting three days or more and observed over a three to seven day period (after its beginning) produces a column density distribution very similar to the one obtained when steady state is reached. The decrease of the maximum intensity (as seen by the V2 instrument) is very slow, i.e., the rate of decrease is slower than 10% per day. This is mainly due to the fact that the hydrogen atoms are produced in 4π steradians. If the outburst lasts less than three days, the central column density increases first and then begins to decrease two to three days after the beginning of the outburst. Once again, the isotropic production of the hydrogen atoms does not allow us to choose the best set of parameters. However, in order to produce a decrease of the intensity by a factor of 2 in 4 days, one or more of the following conditions must be fulfilled: the lifetime of the parent is much shorter than 10^5s at 1 A.U., the velocity of the hydrogen atoms is only of the order 5 km s^{-1}, the outburst lasts less than 4 or 5 hours. The production rate needed to produce the observed intensities is of the order of 6×10^{30} s^{-1} with the above-mentioned values of τ_p and V_H, if the outburst lasts 1 day. It roughly varies as the inverse of the duration of the outburst.

The production rate of the hydrogen atoms parent is likely of the order of 10^{31} s^{-1}, if not higher. This value is one order of magnitude above any measured production rate of water molecules (see Feldman, 1981, for a review). However, it should be kept in mind that comet P/SW1 is known to have a very bright reduced magnitude ($r_h = \Delta = 1$ A.U.): a magnitude of 12 at 5.15 A.U. translates into a reduced magnitude of 4 which is brighter by 4 to 8 magnitudes than any of the faint comets whose water production rate has been measured in the 4-10 x 10^{28} s^{-1} range by Weaver et al. (1981). On the other hand, a comparison with bright nonperiodic comets (water production rates in the 1-5 x 10^{29} s^{-1} range) shows that reduced magnitudes would be similar to that of P/SW1. Although all these comparisons are uncertain since the ratio of the continuum to the gaseous emissions is variable from comet to comet, it seems difficult to escape the conclusion that comet P/SW1 is a very large object. Two additional arguments support this conclusion. First, Whipple (1980) has shown that only part of the nucleus surface is active and second, the energy available at the comet for evaporating parent molecules is 36 times smaller at 6 A.U. than it is at 1 A.U. and this effect is not included in the estimation of the reduced magnitude.

The nature of the parent of the hydrogen atoms cannot be inferred from these observations. The detection of CO^+ ions very close to the nucleus by Cochran, Barker and Cochran (1980) excludes the possibility that these ions are produced subsequent to a photodissociation of an unknown parent. A direct photodissociative ionization would be characterized by a very large time constant and would result in a low density but extended cloud of CO^+ ions (according to Huebner and Carpenter, 1979, the conversion of CO_2 into CO^+, as suggested by Cowan and A'Hearn, 1981, has a very low efficiency and is not likely to occur). Owing to the very high production rate of the H-atoms parent, the formation of CO^+ near the nucleus by charge exchange reactions between the H-parent ions and CO molecules is a tempting alternative production mechanism. However, it requires the H-parent molecules to have a higher ionization potential than CO. Spectroscopic observations of comet P/SW1 are too scarce to allow a discussion of the possibility that CO^+ and H have the same parent molecule.

The non detection of helium (584 Å), neon (736 Å) and argon (1048 Å) can be expressed in terms of upper limits of the production rate of these rare gases, assuming that they are produced continously by a point source and that their radial velocity is 1 km s^{-1}. Steady state upper limits of 1×10^{28} s^{-1}, 5×10^{29} s^{-1} and 1×10^{31} s^{-1} were found for He, Ne and Ar respectively. Our HeI production rate upper limit is much lower than that reported by Riegler and Garmire (1975) in comet Kohoutek.

V. CONCLUSION

The Ly α emission variations measured by the Voyager 2 Ultraviolet Spectrometer while the instrument was pointing in the direction of comet P/SW1 cannot be explained solely by the Ly α emission of the interplanetary medium. The comparison of the characteristics of both HI and HeI interplanetary emissions shows that neither of these two species was strongly focussed behind the Sun. Superimposed on the HI interplanetary signal a Ly α emission of about 50 Rayleighs has been tentatively attributed to the emission of hydrogen atoms coming from the dissociation of an unknown parent molecule released by come P/SW1 (1974II). The production rate of these molecules was probably of the order of 10^{31} s^{-1}. This high value implies that come P/SW1 is an object whose size may be one or two orders of magnitude higher than that of an average comet observed in the vicinity of the Earth. The low upper limit we derived for the production rate of He atoms excludes the hypothesis that rare gases are the triggers of the ourbursts of P/SW1. Future modeling and observations of the interplanetary Ly α emission are needed to confirm the present conclusions.

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