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Extended Atmospheres of Outer Planet Satellites
and Comets

William H. Smyth and
Michael R. Combi

Atmospheric and Environmental Research, Inc.
840 Memorial Drive
Cambridge, MA 02139

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16. Abstract

The new cometary hydrogen particle-trajectory model, completed last year, has been used successfully to analyze observations of Comet P/Giacobini-Zinner. The Pioneer Venus Orbiter Ultraviolet Spectrometer observed the comet at 1216 Å (hydrogen Lyman-α) on 11 September 1985 when the comet was 1.03 AU from the Sun and 1.09 AU from Venus. The analysis implies a production rate at 1.03 AU of 2.3×10^{28} s^{-1} of the water molecules which photodissociate to produce the observed hydrogen. An upper limit for the H_2O production rate of Comet P/Halley of 5×10^{28} s^{-1} at 2.60 AU was also obtained from the Pioneer Venus instrument.

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I. Program of Research for the First Quarter

Research activities during the first quarter have concentrated on the comet portion of this project. Analysis of successful hydrogen observations of Comet P/Giacobini-Zinner by the Pioneer Orbiter Ultraviolet Spectrometer (PVOUS) is discussed below. A paper summarizing these observations and their analysis was presented in October at the AAS/DPS meeting (Stewart, Combi, and Smyth 1985). This represents the second step in our Comet Observing and Analysis Program, a collaborative effort with A.I.F. Stewart, Principal Investigator of PVOUS. The first step involved the successful observations and analysis of Comet P/Encke reported earlier (Combi, Stewart, and Smyth 1984). Nearly continuous observations of Comet P/Halley and their subsequent analysis, to begin in the next quarter, will initiate the third step of this program. From limited observations on September 11, Stewart derived a 3s upper limit of 5 x 10^{28} s^{-1} for the H_2O production rate from a null PVOUS observation of Lyman-a in P/Halley when it was 2.60 AU from the Sun. This is consistent with a vectorial model analysis of IUE OH observations on 12.9 September which implied a production rate of 2 x 10^{28} s^{-1} (Feldman et al. 1985).

<u>Analysis of Pioneer Venus Observations of Comet P/Giacobinin-Zinner</u>

The Pioneer Venus Orbiter Ultraviolet Spectrometer (PVOUS) observed Comet P/Giacobini-Zinner at 1216 / (hydrogen Lyman-a) on 11 September 1985, when the comet was 1.03 AU from the Sun and 1.09 AU from Venus. The field of view of the instrument made 2500 passes across the coma, taking samples every 4.4 x 10^5 km along a swath whose width was 1.7 x 10^6 km. The path of the swath made an angle of about 47° with the comet-sun line as projected on the sky plane. The maximum observed signal was 405 R, including an interplanetary background of 261 R. The fully calibrated and reduced data were provided to us by A.I.F. Stewart.

These data have been analyzed with the AER particle-trajectory model (PTM) based on the production of H atoms by photodissociation of H_2O and OH. This model, developed under this and previous NASA contracts, calculates exact atom trajectories in three dimensions taking into account both variable solar radiation pressure and solar gravity, and includes the fully time-dependent spatially extended random ejection directions of photodissociated atoms and radicals.

The numerical parameters of the model are the same as those used previously for the Lyman-α P/Encke observations (Combi, Stewart, and Smyth 1984) and are scaled in the PTM appropriately for the orbit of P/Giacobini-Zinner. Therefore, all time, heliocentric distance, and heliocentric velocity dependences are automatically taken into account. The H_2O production rate was assumed to vary as the inverse cube of the heliocentric distance, as is appropriate for H_2O sublimation near 1 AU.

Figure 1 shows a comparison of the observed Lyman-α scan with the modeled scan. The model output includes the trapezoidal slit function appropriate to the PVOUS data. The model analysis implies a water production rate of 2.3×10^{28} molecules s^{-1} from Comet P/Giacobini-Zinner at the time of the observation. This value is bracketed by the OH production rate of P/Giacobini-Zinner obtained by 18 cm radio observations by Bockelee-Morvan et al. (1985) in August (1.8×10^{28} molecules s^{-1}) and October (2.9×10^{22} molecules s^{-1}). Contour plots of the model two-dimensional Lyman-α intensity as seen by the Pioneer Venus Orbiter as well as seen normal to the comet plane are shown respectively in Figure 2 and Figure 3. Because of the viewing geometry, the distortion of the hydrogen coma due to solar radiation pressure is more obvious in Figure 3 than in Figure 2.

II. Program of Research for the Second Quarter

Research activities during the second quarter in the area of comets will involve preparing model results to be used for initial interpretation of Comet P/Halley data to be obtained by the Pioneer Venus Spacecraft by A.I.F. Stewart starting in late December. Analysis of the PVOUS data will likely be initiated in January 1986 as it is available from Stewart. Additional effort in the second quarter will also be directed toward writing a paper to document the AER particle-trajectory model.

Research activities in the Saturn system will be continued in the second quarter. Significantly improved values of the electron and ion number densities and temperatures in the Saturn magnetosphere are expected early in the second quarter from E.C. Sittler as part of our continuing collaborative effort with him. This information will be used to refine in our Titan hydrogen torus model the lifetime description of H atoms in the Saturn magnetosphere. Exploratory model computations will then follow as we initiate our analysis of the Lyman-α data acquired by the Voyager 1 and 2 spacecrafts and recently properly formatted by D.E. Shemansky for this purpose.

References

Bockelee-Morvan, D., Bourgois, G., Crovisier, J., and Gérard, E. (1985) Radio Observations of OH in P/Halley and P/Giacobini-Zinner. Poster 13.18 presented at the AAS/DPS meeting Oct. 28 - Nov. 1, 1985, Baltimore, MD.

Combi, M.R., Stewart, A.I.F., and Smyth, W.H. (1984) An Analysis of Pioneer Venus Hydrogen Lyman-α Observations of Comet P/Encke. BAAS 16, 638.

Delsemme, A.H. (1982), Chemical Composition of Cometary Nuclei, in Comets, (L. Wilkening, ed.), University of Arizona Press, Tucson, AZ, p. 85.

Feldman, P.D., et al. (1985) IUE Observations of Comet P/Halley in September 1985. BAAS 17 (late paper abstract).

Rottman, G.J. (1985) Private communication.

Stewart, A.I.F., Combi, M.R., and Smyth, W.H. (1985) Lyman-alpha Measurements of P/Giacobini-Zinner. BAAS 17, 686.

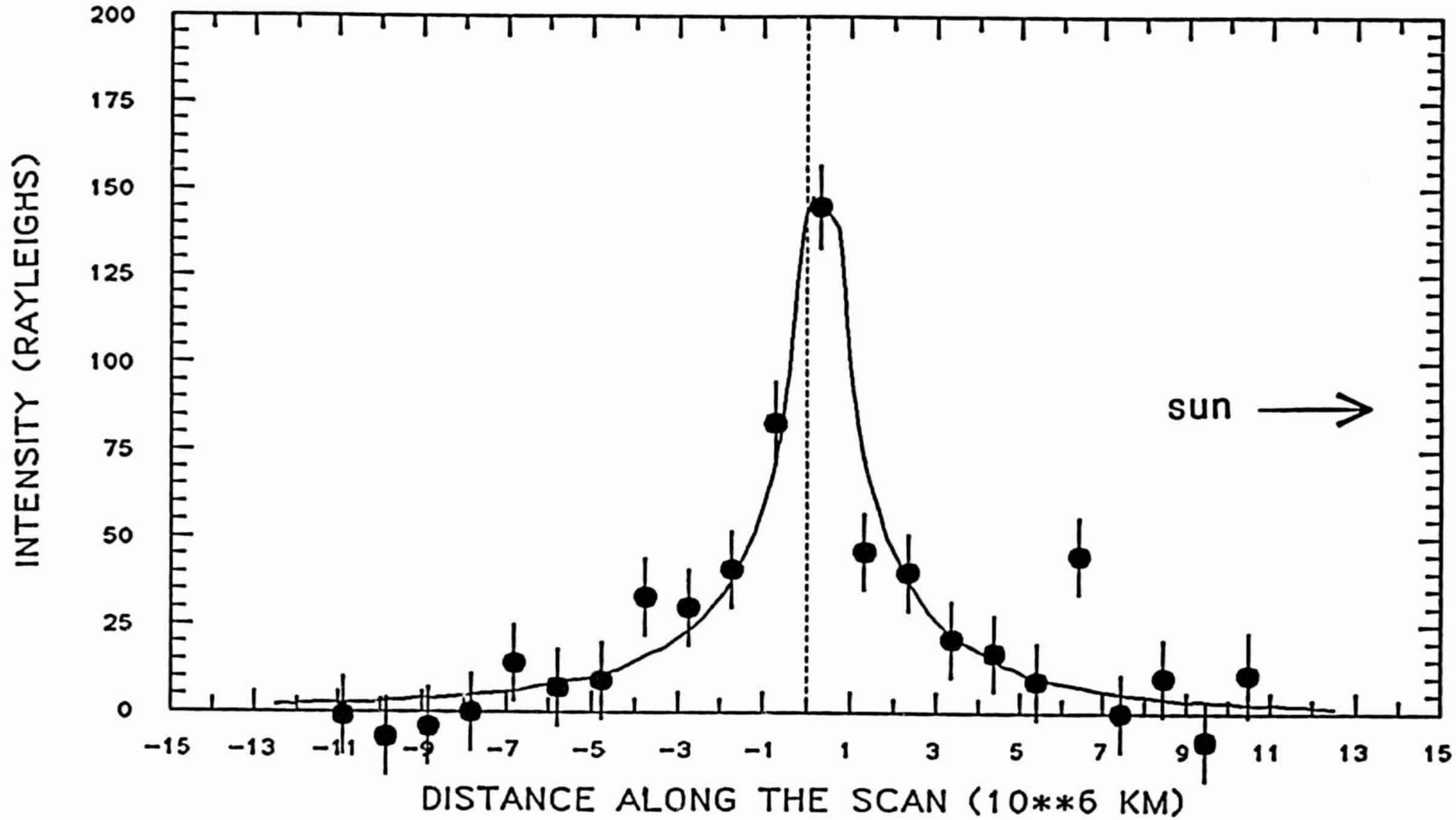

Figure 1

A comparison of the Pioneer Venus observations of Lyman-α from Comet P/Giacobini-Zinner (points) and the PTM (line) analysis is shown. The best model fit yields an H_2O production rate of 2.3×10^{28} s^{-1} at 1.03 AU and is consistent with a hydrogen atom lifetime of 9.4×10^5 s at 1 AU.

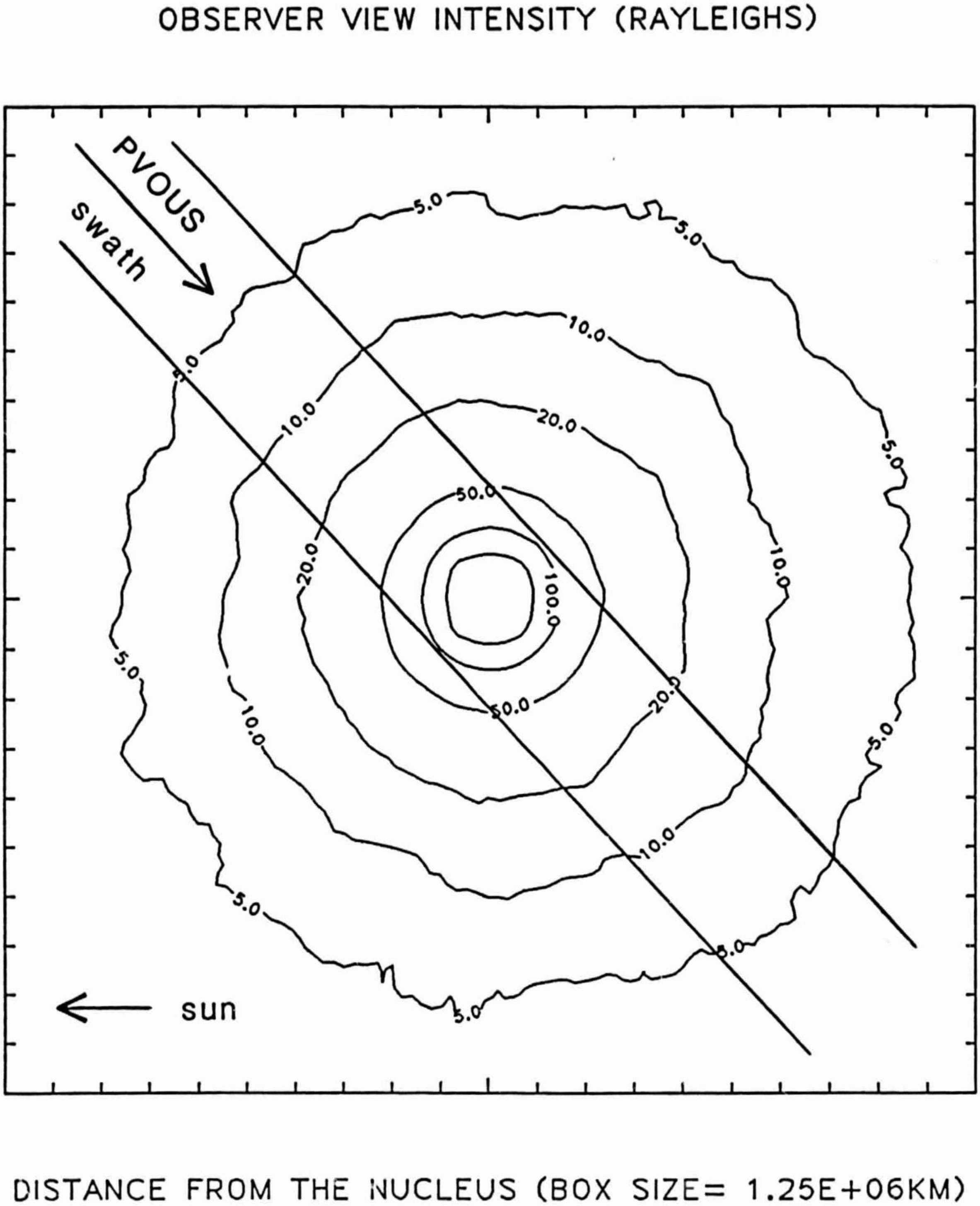

Figure 2

A 2-D map of H Lyman-α from the PTM analysis is shown with the Pioneer Venus Swath. North is down and East is to the left.

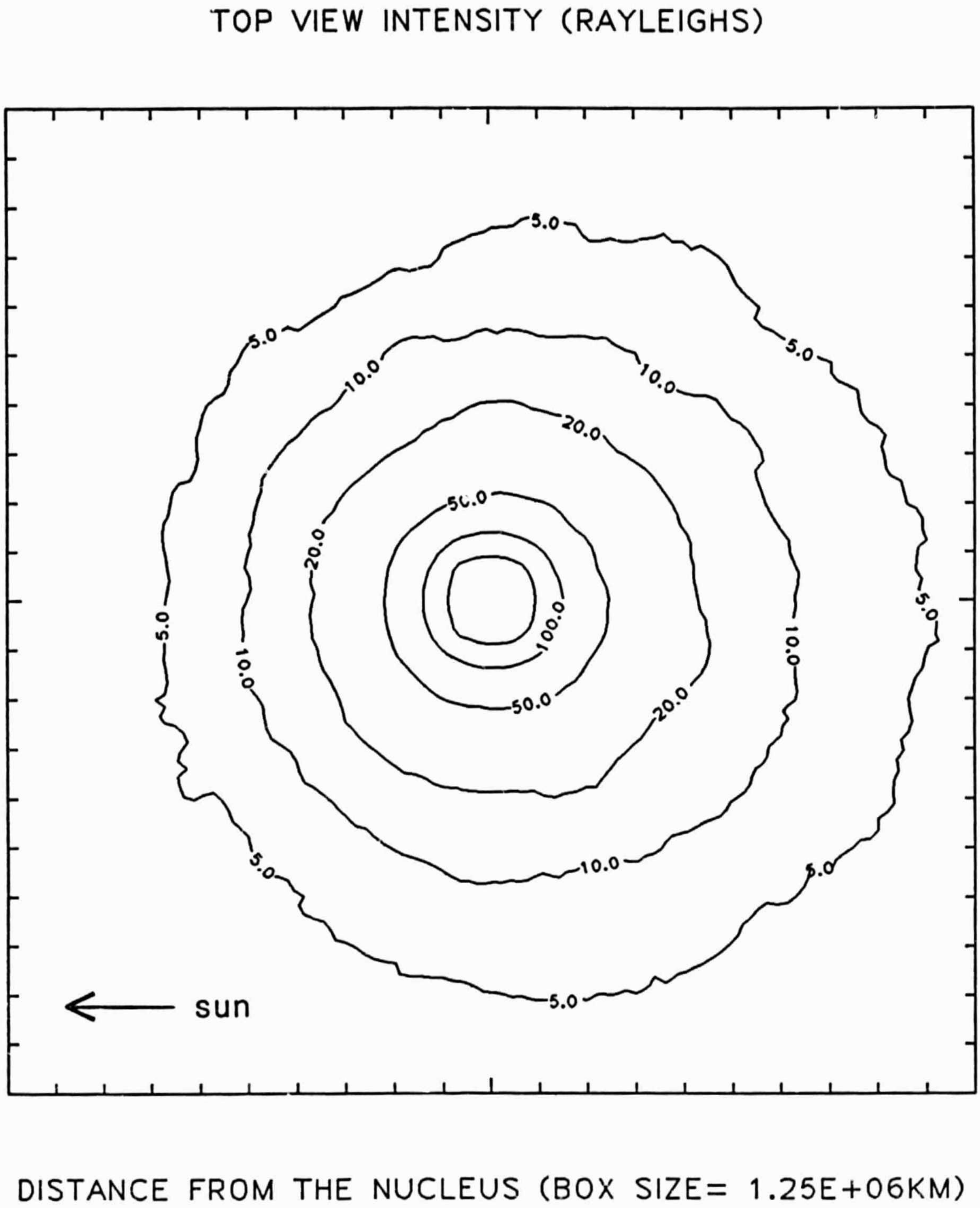

Figure 3

An out-of-plane view of the 2-D H Lyman-α map from the PTM analysis is shown. This view maximizes the apparent radiation pressure distortion.