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ULTRAVIOLET SPECTROSCOPY OF COMETS USING SOUNDING ROCKETS, IUE AND SPACELAB

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Ultraviolet spectroscopy is a very powerful tool for the study of cometary atmospheres since the four elemental cosmic species, H, C, N and O, as well as several simple molecules made from these species, have their strong resonance transitions in the ultraviolet region of the spectrum. However, due to the opacity of the atmosphere to ultraviolet, these observations must be made from space. The first such observations were made by OAO-2 of Comets Tago-Sato-Kosaka (1969 IX) and Bennett (1970 II) (Code et al., 1972), but owing to the large background in the objective grating spectrographs, only HI Lα and the OH (0,0) band at 3085Å were definitively identified. Comets Kohoutek (1973 XII) and West (1976 VI) were observed by sounding rocket experiments (Feldman et al., 1974; Opal et al., 1974; Feldman and Brune, 1976) which offer the advantage of being able to observe at solar elongation angles as small as 20° by using the earth's limb as an occulting disk. The first comprehensive spectra of a comet between 1200 and 3200Å were obtained of Comet West (Feldman and Brune, 1976; Smith et al., 1980) and disclosed the presence of several previously undetected cometary species such as CO, $C(^1D)$, C^+, S and CS. Table 1 summarizes species observed in the vacuum ultraviolet to date.

No new species were observed in the subsequent observations of Comets Seargent (1978m) (Jackson et al., 1979) and Bradfield (1979l) (Feldman et al., 1980) made by the International Ultraviolet Explorer satellite observatory. However, significant new information was obtained from the IUE observations as a result of the high spatial resolution capability of the IUE spectrographs (Fig. 1) and the ability to observe the comet over an extended range of heliocentric distance, as illustrated in Fig. 2. The IUE spectrographs also have a high dispersion capability which so far has been used to obtain high resolution ($\Delta\lambda$ = 0.5-1.0Å) spectra of the OH and CS bands (Fig. 3).

Over the next few years, IUE should remain an important tool for cometary observations although the current 45° solar avoidance cone may expand as the efficiency of the solar power panels decreases with time. For the current apparition of p/Encke, this avoidance requirement limits IUE observations of p/Encke to heliocentric distances of > 0.8 a.u. pre-perihelion (no observations are possible post-perihelion). For complementary observations near perihelion (0.34 a.u.), a sounding rocket launch, utilizing the Faint Object Telescope developed at Johns Hopkins University for extra-galactic sources (Hartig et al., 1980) will be used. The feature of this payload that makes it especially useful for faint comets (there is a m_v = 3 limit for targets that can be tracked directly by existing rocket control system startrackers) is the offset tracking system which includes a slit jaw vidicon camera and a ground control system which allows accurate positioning of the spectrograph slit on the comet image. A larger version of this telescope with a 90 cm mirror, again primarily for extra-galactic astronomy, is being completed for a launch aboard an Aries rocket in February or March 1981. This telescope is the prototype of an instrument to be built for Spacelab or Space Shuttle flights and which should be available for the 1986 apparition of p/Halley. Typical performance parameters of this telescope, when used with a 100 x 100 element array detector to provide spatial imaging along the length of the slit, are given in Table 2.

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Table 1.

	Wavelength (Å)
A. Observed Species	
H I	1216
O I	1304
C I	1561, 1657
C I (^1D)	1931
S I	1814
C II	1335
CO	1510
C_2	2313
CS	2580
OH	3085
CO^+	2200
CO_2^+	2890
B. Upper Limits	
H_2	1608
CO_2	1993
NO	2150

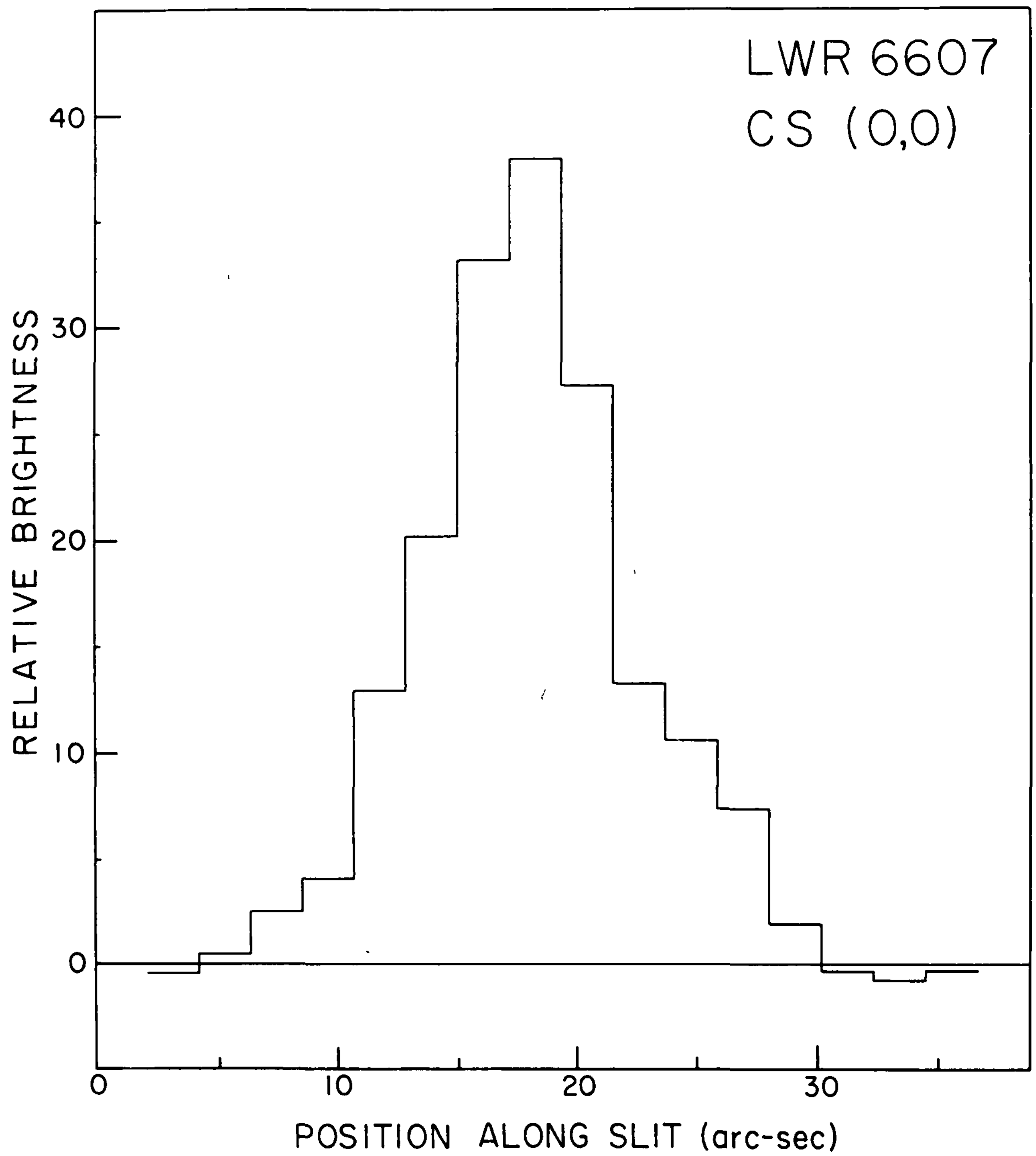

Figure 1. Variation of the CS (0,0) band at 2575Å in the 10" x 20" IUE spectrograph slit. At an effective resolution of 5" this emission appears to be a point source. Data from Comet Bradfield, 10 January 1980.

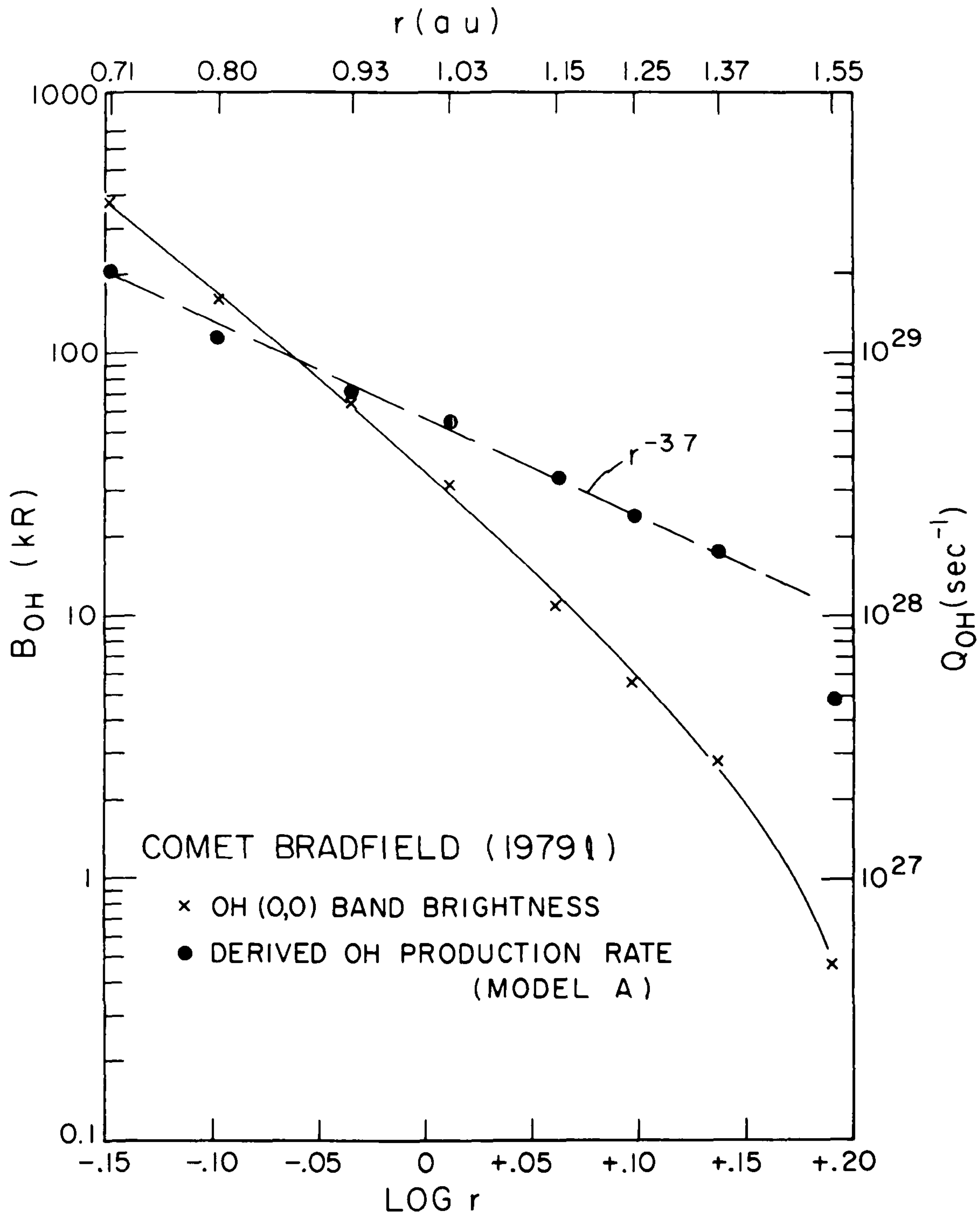

Figure 2. Variation of the brightness of the OH (0,0) band at 3085Å as a function of heliocentric distance. The derived OH production rate is also shown.

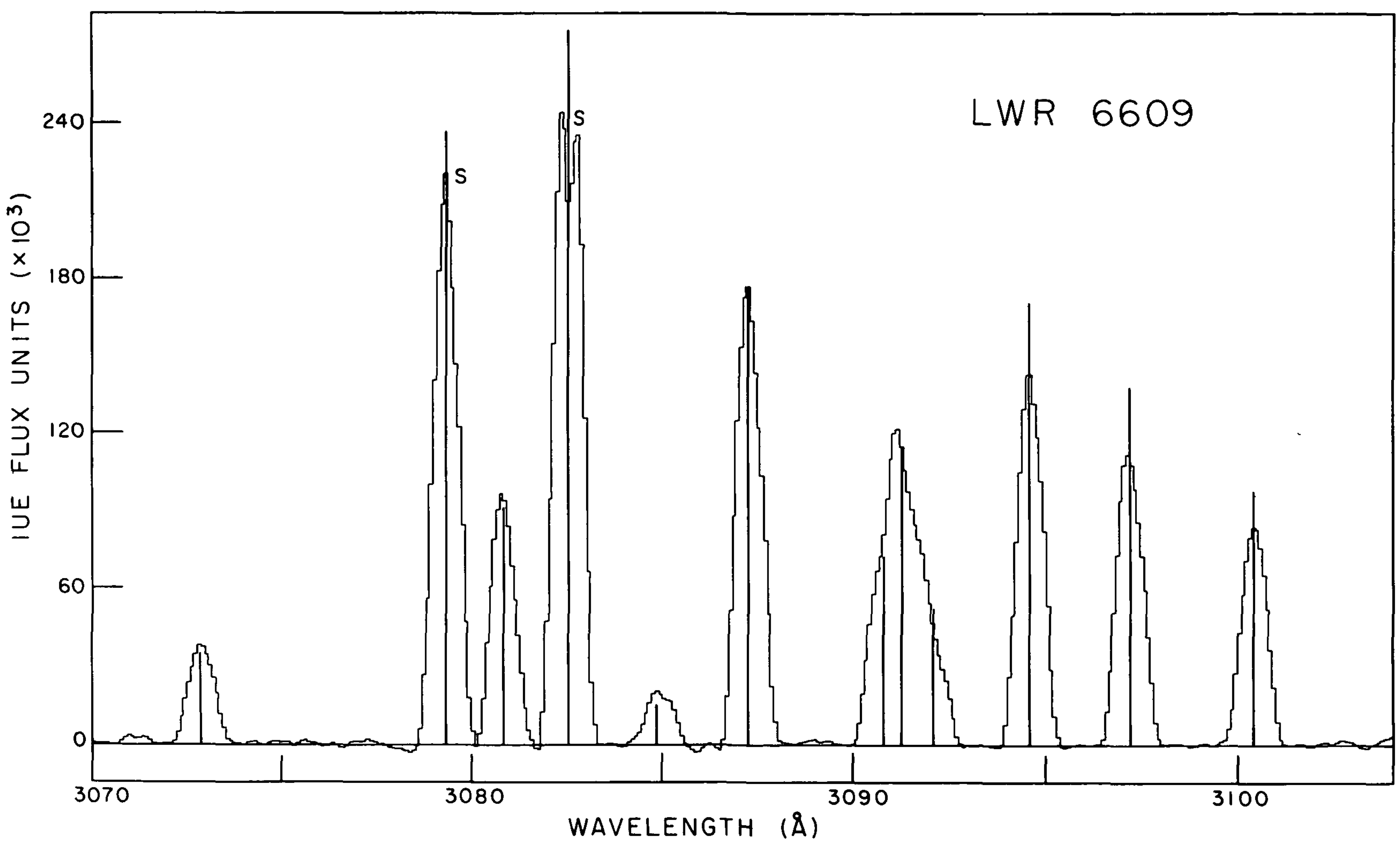

Figure 3. High dispersion spectrum of the OH (0,0) band taken on 10 January 1980 compared with predicted intensities. Saturated lines are denoted by S.

Table 2.

HUT PARAMETERS
(Hopkins Ultraviolet Telescope)

Telescope Diameter	90 cm
Focal Length	200 cm
Pixel Size	40μ x 40μ
Spatial Resolution (at 1 a.u.)	3000 km
Field-of-View (Slit)	4" x 7'
Spectral Range	1200-1850Å (Second Order)
	2100-3200Å (First Order)
Spectral Resolution	22Å; 13Å
Sensitivity (per Pixel)	6 Counts s^{-1} kR^{-1}
Sensitivity (Average in Slit)	600 Counts s^{-1} kR^{-1}

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