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AIR FORCE CAMBRIDGE RESEARCH LABORATORIES
L. G. HANSCOM FIELD, BEDFORD, MASSACHUSETTS

The Solar Extreme Ultraviolet Spectrum Between 30 March 1966 and 17 January 1967

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OFFICE OF AEROSPACE RESEARCH
United States Air Force

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UPPER ATMOSPHERE PHYSICS LABORATORY PROJECT 6688
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The Solar Extreme Ultraviolet Spectrum Between 30 March 1966 and 17 January 1967

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Abstract

The solar extreme ultraviolet spectrum, in the wavelength range 226 Å to 1266 Å, is presented for data obtained from three rocket-borne spectrometers launched during the period 30 March 1966 to 17 January 1967. A positive correlation between the 10.7 cm solar flux and the intensities of the 284.2 Å Fe XV and 335.0 Å Fe XVI lines is shown to exist.

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The Solar Extreme Ultraviolet Spectrum Between 30 March 1966 and 17 January 1967

1. INTRODUCTION

Three rocket-borne spectrometers were launched from the White Sands Missile Range during the period 30 March 1966 to 17 January 1967 by the Air Force Cambridge Research Laboratories to monitor the solar extreme ultraviolet in the approximate wavelength range of 226 Å to 1266 Å. Table 1 summarizes the conditions under which each spectrum was obtained. The measurement technique was similar to that used in obtaining the spectrum published in SPACE RESEARCH III (Hall et al, 1962; Zirin et al, 1962).

Table 1. Summary of Experimental Conditions

Date	Time (MST)	Apogee	Zenith Angle	10.7 cm Solar Flux
30 March 1966	1135 hr	227 km	30°	99.0×10^{-22} watts m^{-2} Hz^{-1}
22 July 1966	1402 hr	245 km	28°	106.5×10^{-22} watts m^{-2} Hz^{-1}
17 January 1967	1200 hr	242 km	56°	116×10^{-22} watts m^{-2} Hz^{-1}

This report is presented primarily to publish the resulting spectra. The details of the monochromator (entrance slit, grating, belt, photomultiplier, and electronics),

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the calibration procedure, and the solar biaxial pointing control will not be discussed. A detailed discussion of the monochromator and the calibration procedure has been published by Hinteregger (1961).

Some mention of the method of determining the flux contours is necessary for an understanding of the applicability of the results. A cursory discussion of the salient features of the spectra is also included.

2. SOLAR SPECTRUM (226 Å to 1266 Å)

The three spectra are presented in Figures 1, 2, and 3. The ordinates represent the telemetered output of the binary counters in 10^3 counts per second. The details of the telemetry system have been discussed by Hinteregger (1961). The abscissae represent the wavelength in angstroms. The flux lines have the units of photons per square centimeter per second and are quantitatively labeled. In order to compensate for limitations in the dynamic range of the displays in the figures, certain lines were arbitrarily allowed to go off scale. In these cases, the flux value is written adjacent to the appropriate wavelength.

Only the stronger lines, including higher order lines, are identified in the figures. The three spectra were corrected for background scattering by assuming a constant scattered-light ratio (independent of wavelength) based upon "signal-to-noise" laboratory calibration data for helium 584 Å and hydrogen 1216 Å. The background level of the scattered light was determined by dividing the appropriate "signal-to-noise" ratio (typically about 5000) into the total count rate of the spectrum (typically about 2.0 to 2.5 × 10^6 counts per second). The latter was determined from a manual integration of the spectrum.

An additional correction factor required to compensate errors in the data reduction (the major contribution being the bandwidth limitation imposed by the Visicorder magnetic oscillograph) was applied. The following expression, where $\chi(\lambda)$ represents the correction factor, was used to determine the solar flux $\phi(\lambda)$ from the telemetered count rate, $n(\lambda)$:

$$\phi(\lambda) = \frac{n(\lambda)}{Y_o(\lambda)\,\eta(\lambda)\,\chi(\lambda)\,A_{ent}} \qquad (1)$$

where

$Y_o(\lambda)$ = absolute photoelectric tungsten yield
$\eta(\lambda)$ = spectrometer efficiency
A_{ent} = spectrometer entrance slit area.

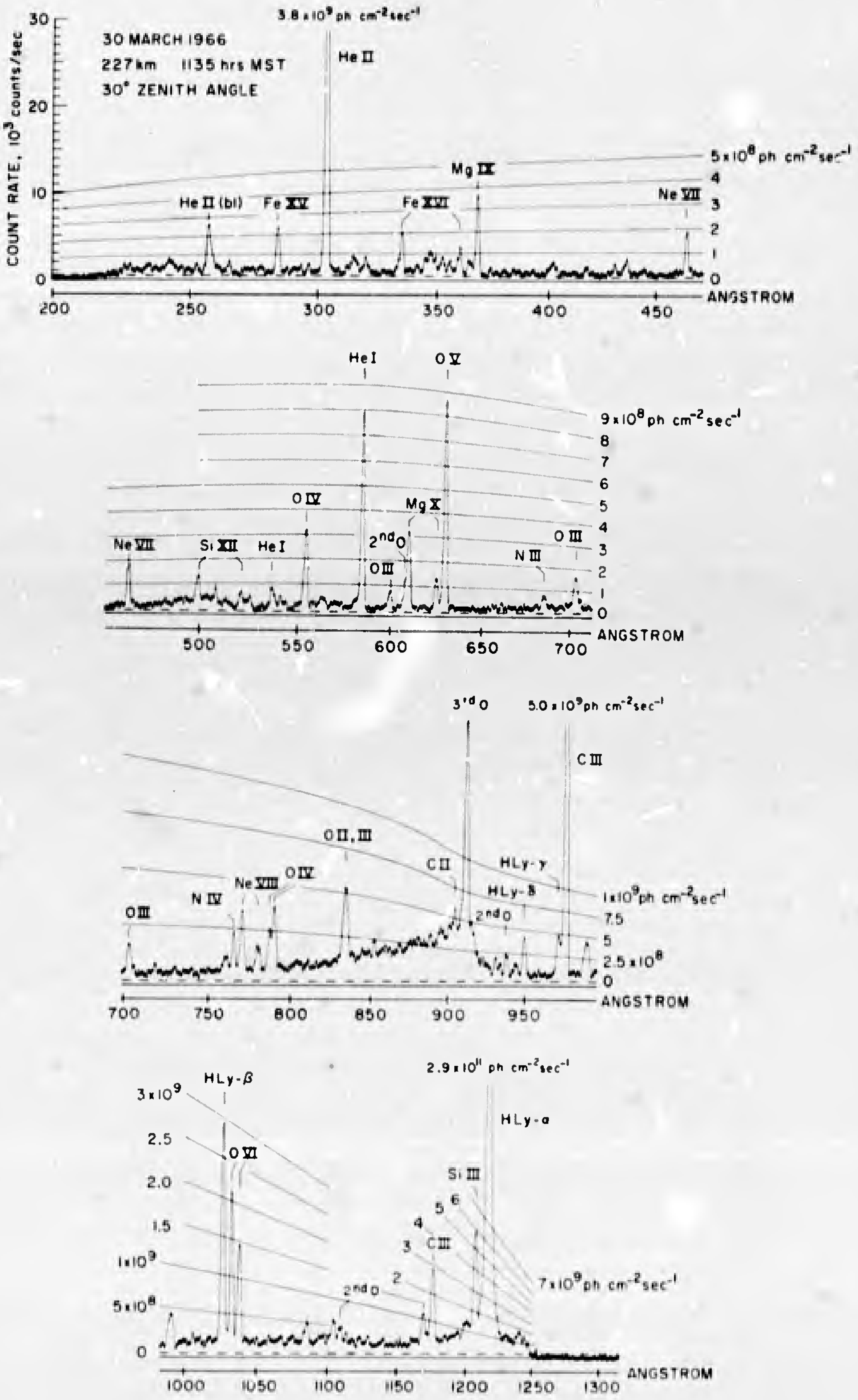

Figure 1. The Solar EUV Spectrum for 30 March 1966

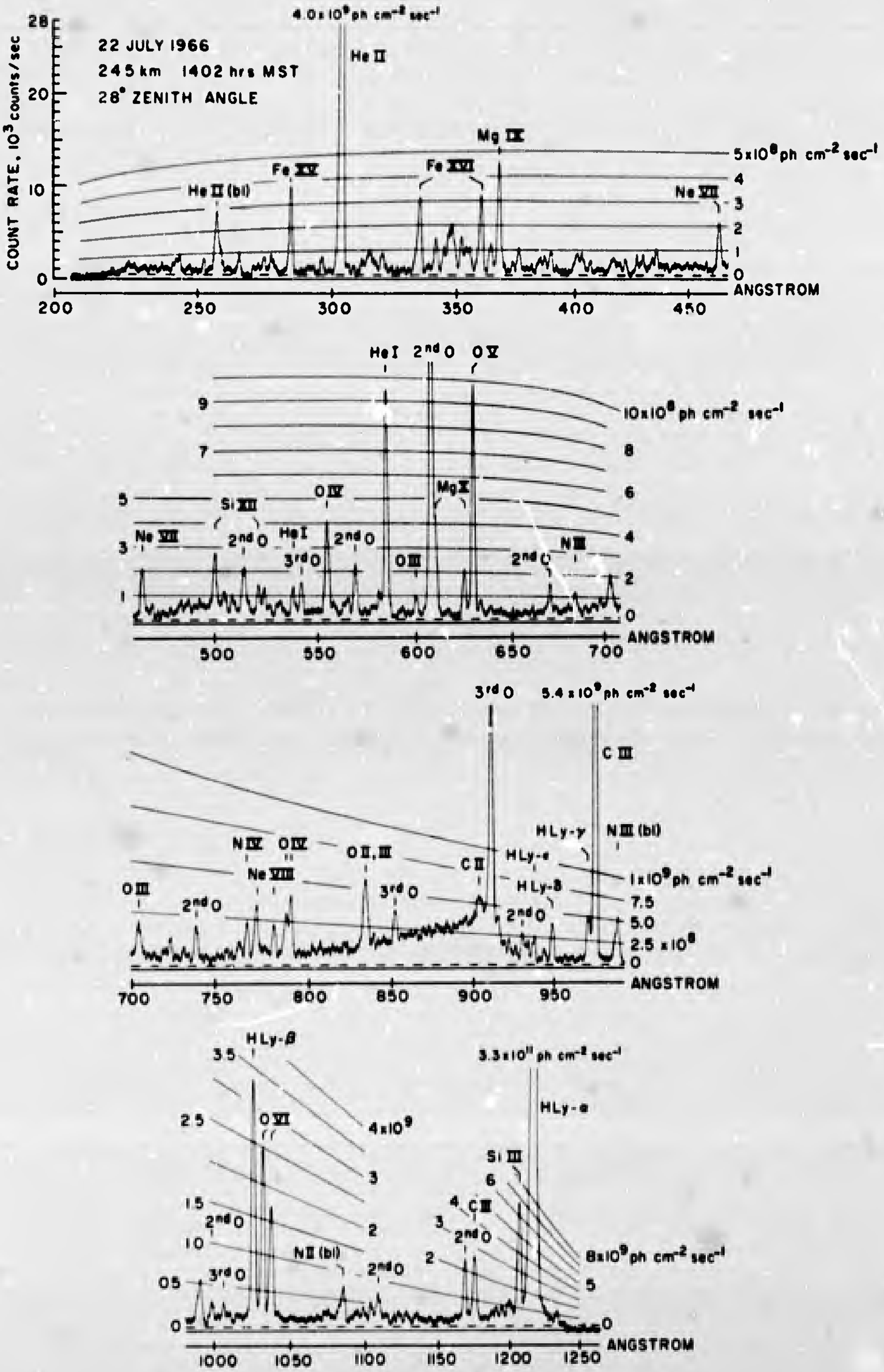

Figure 2. The Solar EUV Spectrum for 22 July 1966

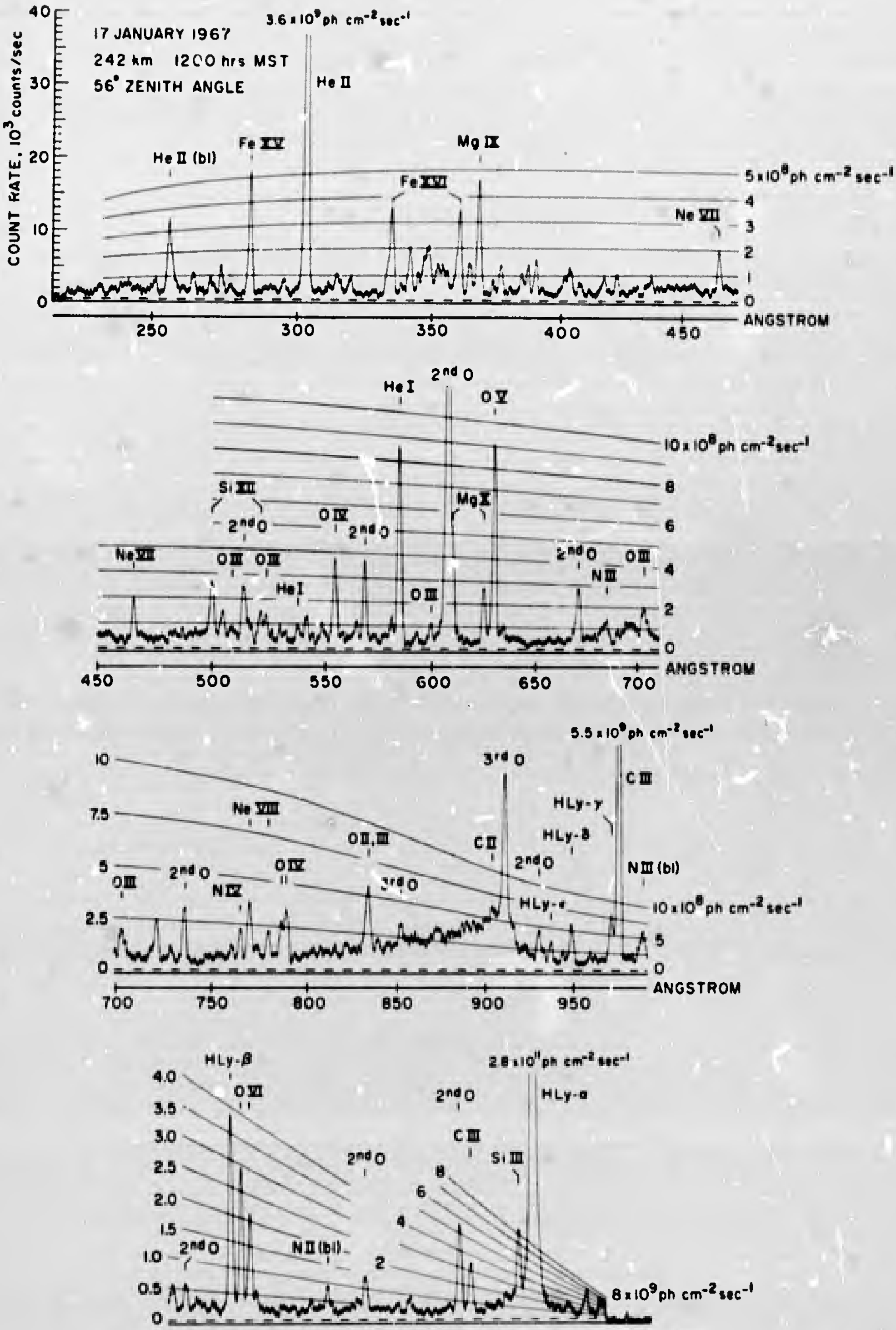

Figure 3. The Solar EUV Spectrum for 17 January 1967

Table 2 lists the values of the absolute photoelectric yield of tungsten that were used in Eq. (1) to obtain Figures 1, 2, and 3. These values of absolute yield were determined by Hinteregger (1954) for the wavelength interval of 1216 Å to 584 Å; they were extrapolated for Table 2 to 200 Å.

Table 2. Tabulation of Absolute Photoelectric Yield of Tungsten as a Function of Wavelength

λ, Å	$\gamma_0(\lambda)$, %
1216	2.0
1100	5.0
1000	7.5
900	10.5
800	14.5
700	15.0
600	14.5
500	12.7
400	10.5
300	8.0
200	5.0

More recent measurements by Heroux et al (1966) have extended the absolute photoelectric yield to shorter wavelengths. These measurements indicate lower values for $Y_0(\lambda)$ below 400 Å than the extrapolated values used in Table 2. At 304 Å for example, $Y_0(\lambda)$ is reported by Heroux et al (1966) to be about 25 percent less than the value used in Table 2. Using Heroux's value, the intensity of the 304 Å line of He II deduced from Eq. (1) would be increased by about 25 percent.

Apart from the aforementioned uncertainty, reasonable limits of error (which result from uncertainties in the calibration procedure) may be ascribed to certain wavelength portions of the spectra. Based upon information garnered from repeated laboratory measurements and the magnitude of the count rates involved, the flux values in Figures 1 to 3 are probably accurate above 584 Å to ± 10 percent, between 584 Å and 304 Å to ± 20 percent, and below 304 Å to ± 30 percent.

An uncertainty also results from assuming a constant scattered-light ratio throughout the spectrum. However, the background contributed by scattered light is generally less than 500 counts per second. Consequently, the majority of the stronger lines would be unaffected by "signal-to-noise" errors.

3. DISCUSSION OF THE SPECTRA

Table 3 is a tabulation of absolute flux measurements for the three spectra of

Figures 1, 2, and 3. The wavelength selection was confined for the most part to the list published in SPACE RESEARCH V by Hinteregger et al (1964). The use of the 284.2 Å Fe XV and the 335.0 Å Fe XVI lines as monitors of solar activity was reported by Hall (1965). These lines are included in Table 3.

Table 3. Flux Measurements of Selected Wavelengths

Wavelength (Å)	Flux (10^{9} ph cm^{-2} sec^{-1})		
	30 Mar 66	22 July 66	17 Jan 67
1215.7 (H Ly-α)	290.0	330.0	280.0
1206.5 (Si III)	6.0	6.6	8.4
1175.7 (C III)	2.9	2.6	3.5
1085.7 (N II)	0.50	0.75	0.90
1037.6 (O VI)	1.48	1.70	2.10
1031.9 (O VI)	2.2	2.5	3.0
1025.7 (H Ly-β)	2.9	3.3	3.9
991.5 (N III)	0.45	0.53	0.60
977.0 (C III)	5.0	5.4	5.5
972.5 (H Ly-γ)	0.50	0.50	0.75
949.7 (H Ly-δ)	0.44	0.40	0.60
937.8 (H Ly-ϵ)	0.25	0.25	0.35
790.1 (O IV)	0.40	0.40	0.37
787.7 (O IV)	0.25	0.30	0.28
780.3 (Ne VIII)	0.18	0.23	0.22
770.4 (Ne VIII)	0.35	0.33	0.37
765.1 (N IV)	0.24	0.25	0.23
703.8 (O III)	0.17	0.22	0.20
629.7 (O V)	0.87	0.98	0.90
625.0 (Mg X)	0.13	0.20	0.27
584.1 (He I)	0.79	0.95	0.86
368.1 (Mg IX)	0.37	0.46	0.46
335.0 (Fe XVI)	0.20	0.30	0.37
303.8 (He II Ly-α)	3.8	4.0	3.6
284.2 (Fe XV)	0.24	0.38	0.52
256.3 (He II)	0.26	0.29	0.36

To account for the unavoidable differences between the three rocket-borne experiments (cf Table 1), the intensities must be corrected for atmospheric attenuation. The techniques for doing this were explained by Hinteregger (1962). A forthcoming paper by Hall et al (1968) will include the data in Table 3 corrected for atmospheric absorption.

The aforementioned differences are not sufficient, however, to mask the positive correlation between the 10.7 cm solar flux and the intensities of the 284.2 Å Fe XV and 335.0 Å Fe XVI lines, as shown in Tables 1 and 3.

When analyzing the three spectra, an attempt was made to determine the presence of a continuum of radiation or a multitude of small unresolved lines "beneath" the spectra. However, the statistics involved prevented a firm conclusion. The best that one can say is that the presence of a continuum in the spectra has not been proved.

4. SUMMARY

The general character of the three spectra presented here is essentially the same as that for the spectrum published by Hall et al (1962). The 284.2 Å Fe XV and 335.0 Å Fe XVI lines show a trend towards increasing intensities as solar maximum is approached.

Because of experimental differences (cf Table 1), no statement will be made concerning the other line intensities. A more detailed analysis will be published by Hall et al (1968).

5. FUTURE PLANS

An investigation of the presence of a continuum of radiation or a multitude of unresolved low count rate lines is planned. The statistical limitations mentioned earlier will be minimized in future experiments with the use of a new family of Bausch and Lomb replica gratings possessing high efficiency characteristics and excellent scattered light properties.

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