X-613-64-333

NASA TMX-55148

N65-18266
(ACCESSION NUMBER)
10
(PAGES)
TMX-55148
(NASA CR OR TMX OR AD NUMBER)
FACILITY FORM 602

(THRU)
1
(CODE)
14
(CATEGORY)

GPO PRICE $
OTS PRICE(S) $
Hard copy (HC) $1.00
Microfiche (MF) $0.50

AN ULTRAVIOLET ROCKET STELLAR SPECTROMETER

BY
DAVID U. WRIGHT, JR.

NOVEMBER 1964

NASA
GODDARD SPACE FLIGHT CENTER
GREENBELT, MARYLAND

Presented at the ICO Conference on Photographic and Spectroscopic Optics, Tokyo and Kyoto Japan, September 1 through 8, 1964. To be published in a supplement to the Japanese Journal of Applied Physics, May 1965

AN ULTRAVIOLET ROCKET STELLAR SPECTROMETER

by

David U. Wright, Jr.
Goddard Space Flight Center
National Aeronautics and Space Administration
Greenbelt, Maryland

U. S. A.

ABSTRACT

18266

The Ultraviolet Rocket Spectrometer (UVR) was developed to measure stellar spectra in the wavelength interval 1100Å to 4000Å. The UVR consists of a 33 cm Dall-Kirkham telescope which provides input to a spectrometer utilizing a plane grating in convergent light. The f/#11.9 system is such that the apparent coma of the plane grating is compensated for by the coma of the tilted spherical spectrometer mirror. Two exit slits are located at compromise focal positions and cover the total scan of 2900Å in two bands with a central overlap of approximately 1300Å. Spectral scan is cam operated and grating position is indicated by a marker generator related to cam rotation. The absolute response function of the flight unit is established by the simultaneous exposure of the calibrated photomultipliers (PMT) and the UVR to the same monochromatic beam of collimated light. Analyses of spectra recorded in the laboratory indicate performance consistent or better than the 3Å equivalent width of the UVR exit slits.

I. INTRODUCTION

The UVR was developed to measure stellar spectra in the wavelength interval 1100Å to 4000Å. The Kollmorgen Corporation of Northampton, Massachusetts designed and fabricated the instrument under the direction of the Goddard Space Flight Center of the National Aeronautics and Space Administration. The ray tracing techniques utilized in developing the optics system were presented to the Optical Society of America in 1963[1].

II. DESCRIPTION OF THE UVR.

The UVR is intended to be mounted parallel to the longitudinal axis of the 38 cm diameter Aerobee rocket. The basic instrument is approximately 33 cm in diameter, 163 cm long and weighs 45.5 kg. As a flight unit with nose cone and miscellaneous items the weight is increased by roughly 12 kg and the length by 115 cm. It consists of a spectrometer and the largest aperture collecting optics consistent with the rocket diameter and the necessary support structure. The UVR is illustrated to scale in Figure 1.

In order to minimize the number of surfaces, the plane grating is illuminated in convergent light resulting in a comatic image[2]. Corrective coma is introduced into the convergent beam by tilting the spherical spectrometer mirror. Both comae are linear function of wavelength. The lower "V" shaped plot in Figure 2 is the result of correcting the grating coma at mid-wavelength by mirror tilt. The grating coma dominates at the higher wavelengths and the coma due to the tilted mirror at the lower wavelengths. In the UVR, an f/11.9 system, the mirror tilt necessary to minimize the aberrations at mid-wavelength, 2550Å, is computed to be 2.3744°.

The spherical aberration contributed by the spectrometer mirror requires that the collecting optics be over-corrected. The result is a classical D-K telescope with its secondary shifted out of position longitudinally, see Figure 1. The final position of the telescope secondary is 0.584 cm from its D-K position toward the primary and causes the telescope focal point to shift 3.233 cm to the plane of the entrance slot. Under these conditions the telescope is over-corrected by the proper amount and sign necessary in order to minimize all aberrative contributions the UVR makes to line width.

The UVR will normally utilize the two exit slits indicated in Figure 1. The slits are located at compromise focal positions and cover the total scan of 2900Å in two bands with a central overlap of greater than 1300Å. The exit slit width was chosen for the flight units to be equivalent to 3Å or approximately 0.015 cm.

The UVR is thus essentially "exit slit limited" and the performance indicated by the respective exit slit curves in Figure 2 cannot be realized. Except as indicated by the reference to "exit slit limited", Figure 2 is therefore the computed performance of the flight units. Actually, if the grating drive could be slowed down enough, it should be possible to decipher the contribution that the UVR makes to line width.

Figure 3 illustrates the focal surfaces to which an appropriate emulsion must be formed in order to use the UVR as a spectrograph. The relationship of grating positions and the respective focal surfaces to the exit slits indicate that some advantage can be taken of the fact that all of the focal surfaces have a radius of 29.21 cm. In the nominal or B_o position of the grating the optimized wavelength, 2550Å, would fall on the optical axis and the emulsion should record the wavelengths from roughly 2000Å to 3000Å. Also take note in Figure 3 of the focal surface for zero order image.

III. DEMONSTRATED PERFORMANCE OF A UVR FLIGHT UNIT

The Majority of the stars which are visible to the human eye from the ground have effective temperatures whose wavelength of maximum radiance is below 3000Å. The earth's atmosphere is opaque to radiation of wavelength shorter than 3000Å. Observations at the shorter wavelengths are therefore necessary in order that theoretical progress can be made.

The UVR, as a payload for the Aerobee, can spend about 300 seconds above 100 km. The entire 300 seconds are not available for observation nor is it desirable to expend the large amount of effort for one observation. It is of great importance to be able to observe several stars of choice. Therefore, the UVR flights will have programmed guidance and do require the same.

The spectra of one or more, probably two, stars of 3rd magnitude or brighter will be the targets of immediate inquiry.

The flight detectors mounted at slit #1 and #2 are EMR type 542F-08 and 542D-03 respectively. The former has a Cs-Te photocathode and a LiF window while the latter has a Bi-alkali photocathode with a sapphire window.

Figure 4 is a reproduction of Cd spectra and the related marker generator signals recorded using the flight detectors, laboratory electrometers and recorder. Spectral scan is cam operated with the angular position of the cam indicated by a marker generator physically related to the cam. Proceeding from a point midway between the two pulses of short duration on the left of Figure 4 to the corresponding point in the pulse train on the right is a complete revolution of the cam and took 57.5 seconds. In this interval, 41.3 seconds was consumed by a slow spectral followed by 9° of cam dwell and 13.4 seconds for a fast spectral scan return and its 9° cam dwell. The prominent spectral features indicated from left to right in the record for slit #1 are 3261, 2981, 2881, 2288, 2265 and 2144Å's. In the same manner, the spectral features indicated in the record for slit #2 are 3611, 3466, 3404, 3261, 2981, 2881, 2288 and 2265Å's. The fast scan in each case is a repetition in reverse of what was recorded during the slow scan. All of the structure indicated has been identified as due to the emission from Cd.

The final calibration and alignment of the UVR is performed within a vacuum calibration tank. The tank houses a 40 cm D-K telescope which collimates the output of a vacuum monochromator. The absolute response function of the flight unit is established by the simultaneous exposure of calibrated PMT's and the UVR to the same monochromatic collimated beam.

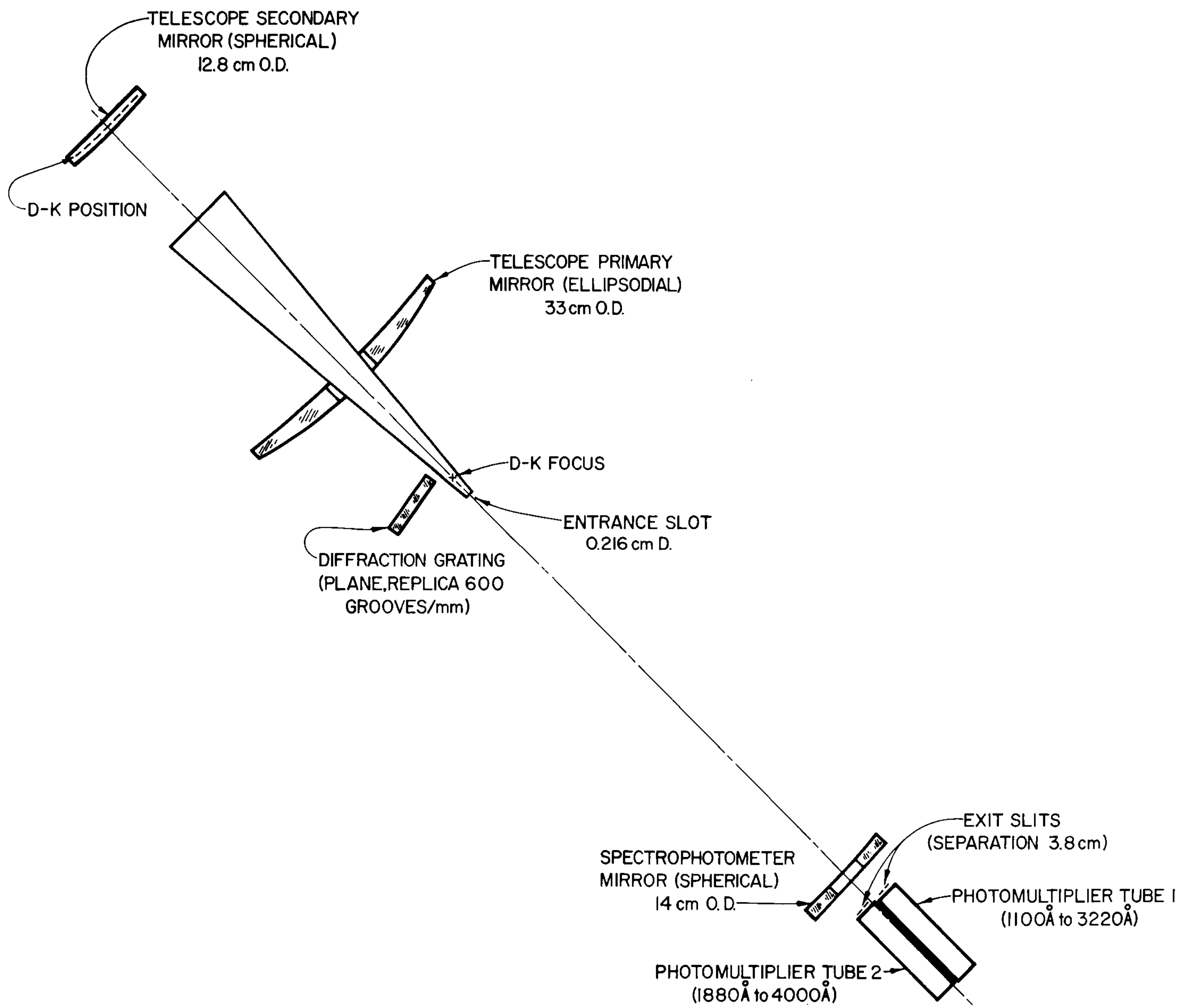

FIGURE 1: UVR OPTICAL LAYOUT

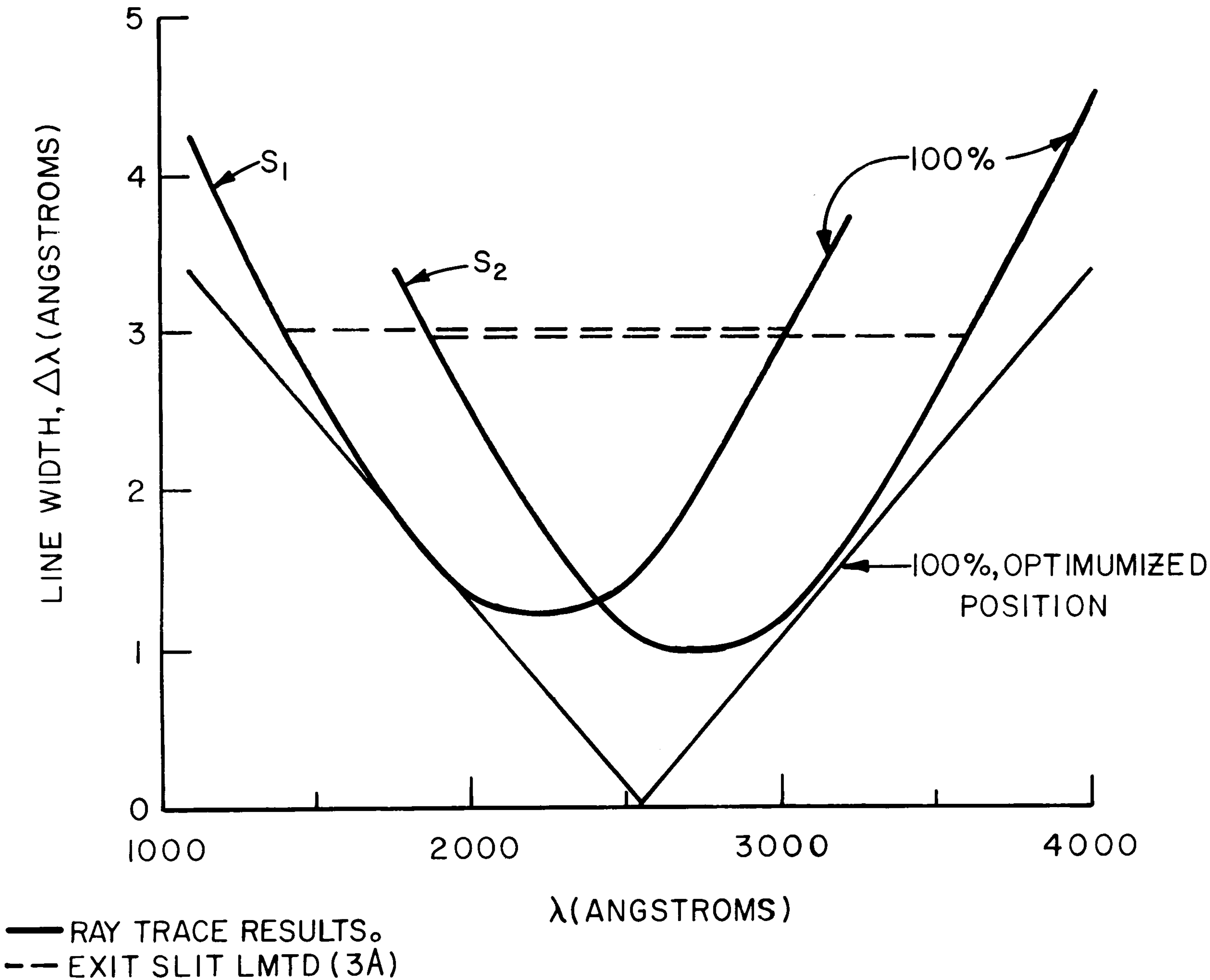

FIGURE 2: COMPUTED UVR PERFORMANCE

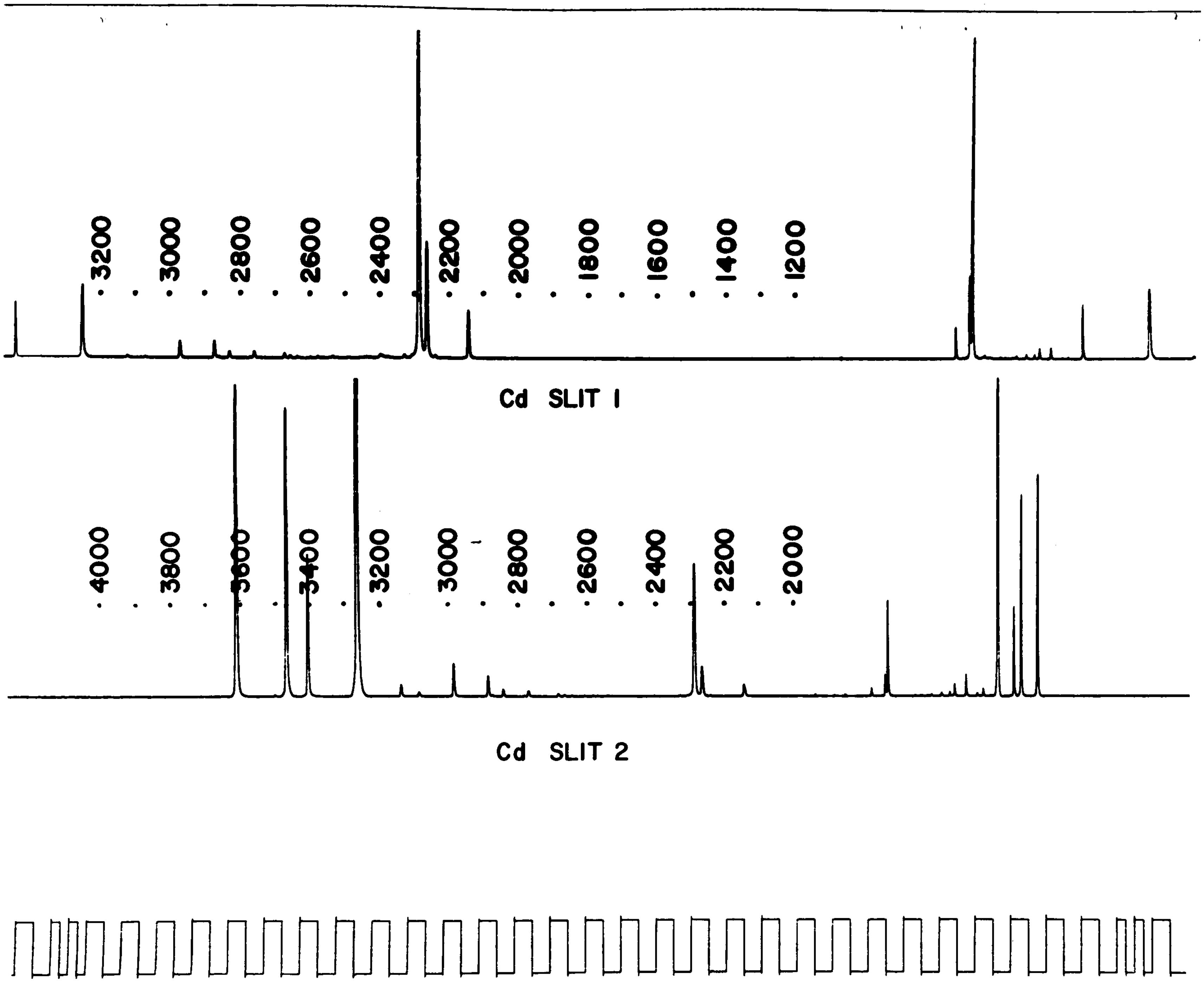

FIGURE 4: RECORDED SPECTRA OF CADMIUM

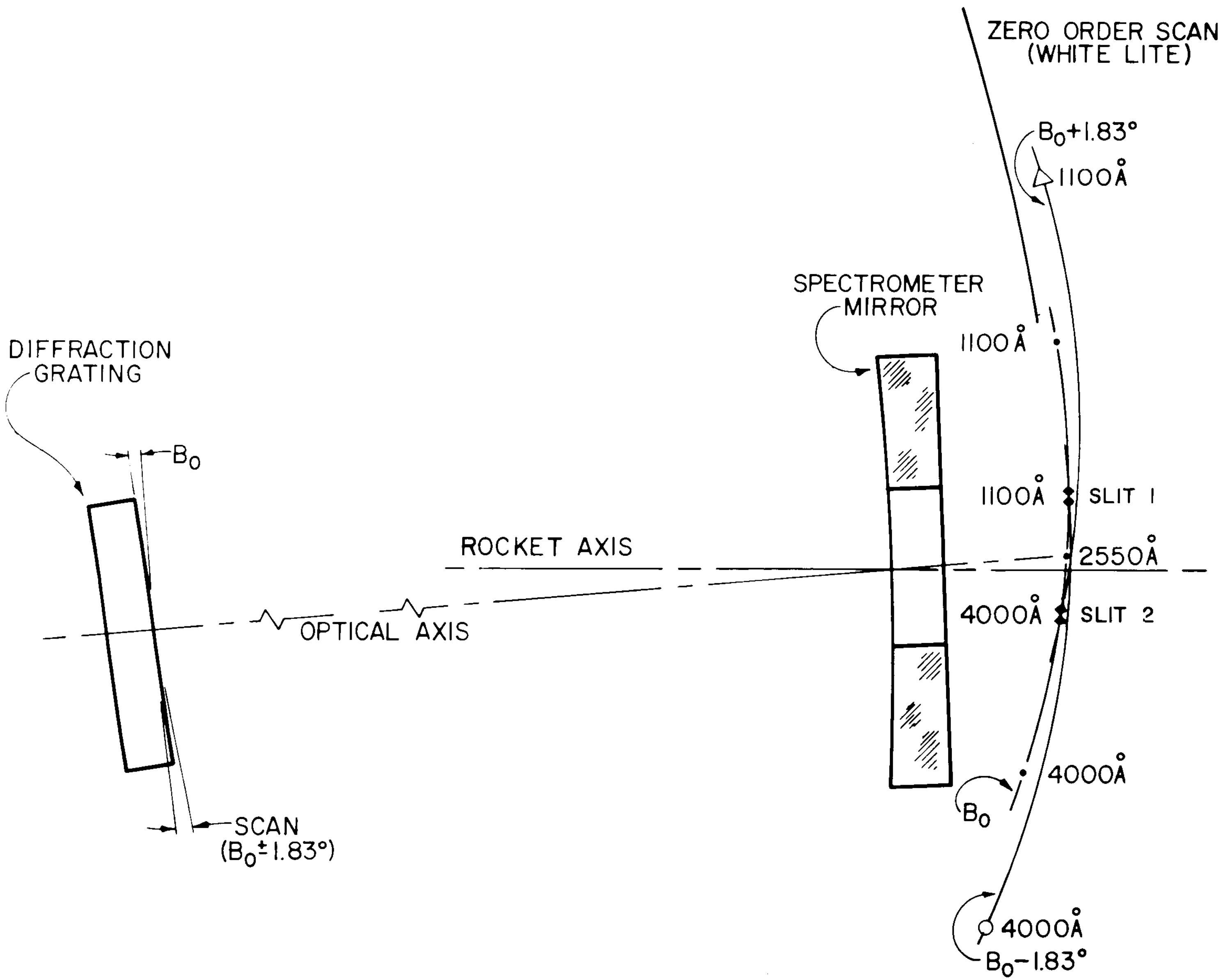

FIGURE 3: UVR FOCAL SURFACES

REFERENCES

1. H. R. McKinley, J. Opt. Soc. Am. 53 (1963) 518A.

2. M.V.R.K. Murty, J. Opt. Soc. Am. 52 (1963) 768.