Historical Celebration – 1958 – 1967 – 60 yrs UV Astronomy

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Kupperian, Boggess, Milligan 1958

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OBSERVATIONAL ASTROPHYSICS FROM ROCKETS
I. NEBULAR PHOTOMETRY AT 1300 A

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ABSTRACT

The techniques of rocket astronomy with photon counters has been advanced so that observations with 3° resolution are possible A survey of the winter sky in the spectral region 1225–1350 A has been made with this resolution Numerous extended sources of high surface brightness have been discovered These sources tend to occur near O and B stars A nebula, 22°.5 in diameter, around α Virginis is discussed The flux at the earth from this nebula is 1×10^{-5} erg/cm²/sec, while α Vir itself has not been detected An upper limit for the stellar flux is set at 2×10^{-7} erg/cm²/sec Ordinary atomic recombination processes cannot account for the high nebular flux observed in this wave-length region Collisional processes or the degradation of stellar energy above 912 A might provide an explanation

INTRODUCTION

Far-ultraviolet radiation in the wave-length band 1225–1350 A from celestial sources other than the sun was first detected during a rocket flight on the night of November 17, 1955 (Byram, Chubb, Friedman, and Kupperian 1957*a*, *b*). Although only a limited area of the sky was scanned and the collimation of the detector was rather broad, about 20°, a strong source was found in the Puppis-Vela region, and weaker sources were detected elsewhere. This flight demonstrated that enough energy reaches the earth's upper atmosphere to make astronomical observations possible and that quantitative measurements essentially free from atmospheric absorption and emission can be obtained. Accordingly, a more comprehensive and higher-resolution experiment was planned to survey the winter sky. This experiment was carried out successfully on March 28, 1957, with an Aerobee rocket launched from White Sands Proving Ground, New Mexico.

The experiment was designed to discover the nature of sources radiating in the 1225–1350 A region and to measure the intensity of that radiation. In addition, detectors sensitive to other wave lengths in the near and far ultraviolet, including Lyman-α (Kupperian, Byram, Chubb, and Friedman 1958), were flown in an attempt to discover other spectral regions suitable for astronomical photometry. The rocket also contained a number of narrow band-pass photoelectric photometers, sensitive to various emission lines in the visible spectrum of the night airglow (Tousey 1958). The present paper contains a description of the far-ultraviolet detectors, their calibration, and their employment in the rocket. The data obtained in the 1225–1350 A region will be summarized in

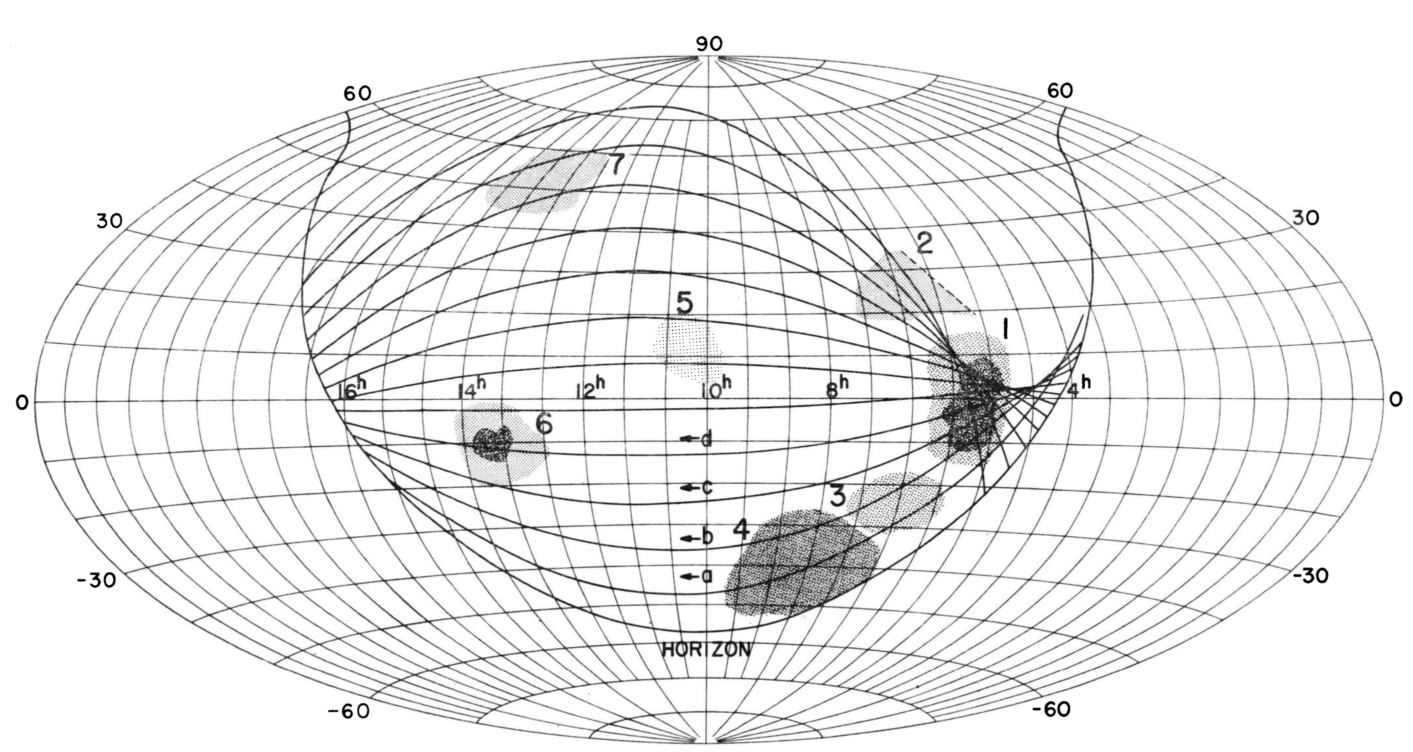

FIG. 3.—Map of the sky at 1225–1350 A in equatorial co-ordinates. Scans of tube 19 across the sky are illustrated, along with the bright regions listed in Tables 2 and 3. The degree of shading corresponds to the relative intensities given in these tables.

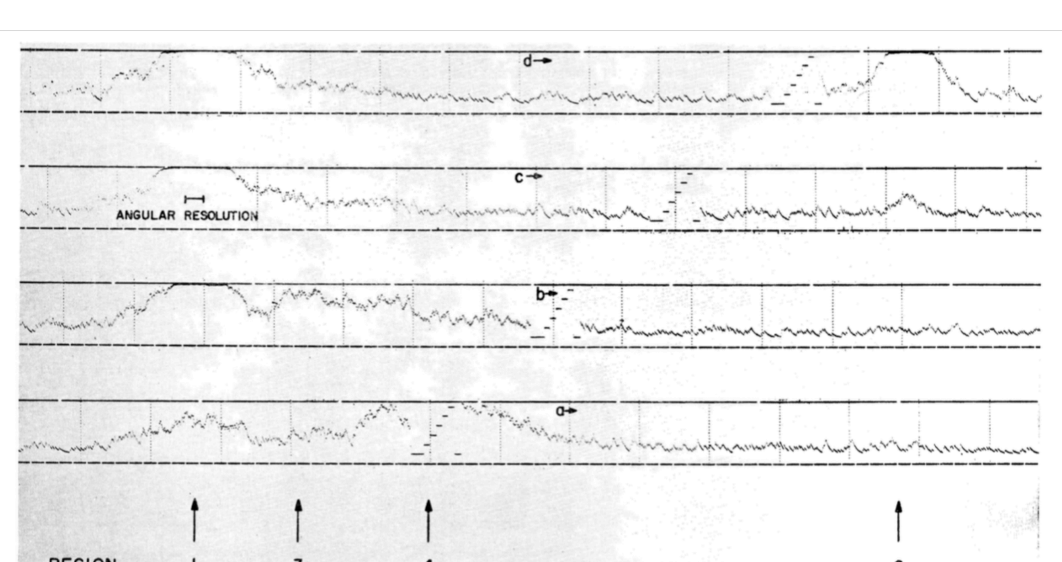

FIG. 2.—Telemeter trace of tube 19. The lettered arrows identify the scans indicated in Fig. 3. This photometer saturated when passing through Regions 1 and 6. At low intensities individual counts can be distinguished. Vertical time marks define half-second intervals.

Spitzer & Zabriskie 1959

INTERSTELLAR RESEARCH WITH A SPECTROSCOPIC SATELLITE*

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The accelerating pace of satellite development may make possible within a few years the launching of relatively complex orbital vehicles, suitable for detailed astronomical observations. While satellite research to date has necessarily been limited to relatively simple observations, mostly of phenomena within the solar system, future satellites should be able to make controlled spectroscopic observations of stars and nebulae, as well as of the sun. The astronomical importance of such detailed information in the far ultraviolet can scarcely be overestimated.

One of the fields most affected by this powerful new observational tool should be the study of the interstellar gas. Most of our limited information about the detailed space and velocity distribution of the interstellar gas within a few thousand parsecs of the sun, and on the ionization and chemical composition of this material, has been obtained from the interstellar absorption lines of sodium and calcium in the visible spectra of the hotter stars (spectral types O and B). While these lines are reasonably strong, and readily measurable, the data they provide are quite limited, and permit only a very introductory survey of the interstellar gas. In particular, most sodium and calcium atoms are in higher stages of ionization (Na^+, designated as Na II, and Ca^{++}, designated as Ca III), and to determine their densities a correction must be made for the ionization level. In principle, this correction can be made from a measurement of the relative number of neutral and singly ionized calcium atoms; this measurement also provides a determination of the electron density. Unfortunately, the λ 4227 line of neutral calcium is so weak that it has been detected in the spectra of but few stars, with accurate measures in only one case. Another shortcoming of the calcium and sodium lines is that they yield so little information on the general composition of the gas;

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TABLE I

RESONANCE LINES OF ABUNDANT ATOMS LONGWARDS OF 912 Å

Spectrum	Abundance	Wavelengths (Å)			
H	1000.	1215.7	1025.7	972.5	949.7
H_2	?	1108.1	1092.2	1077.1	1062.9
C I		1656.9	1560.3	1328.8	1280.2
II	0.09	1334.5	1036.3		
III		977.0			
IV		1550.8	1548.2		
N I	0.2	1200.7(3)	1135.0(3)	965.1(3)	
II		1084.0	915.6		
III		989.8			
V		1242.8	1238.8		
O I	0.5	1355.6	1302.2	1039.2	1025.8
VI		1037.6	1031.9		
Mg I		2852.1	2025.8	1828.2	
II	0.06	2802.7	2795.5	1240.4(2)	1026.1(2)
Si I		2514.3	2438.8	2208.0	2065.5
II	0.04	1808.0	1526.7	1304.4	1260.7
III		1895.5	1206.5		
IV		1402.7	1393.7		
S I		1900.3	1807.3	1474.5(3)	1473.0
II	0.02	1259.5	1253.8	1250.5	
III		1190.2	1012.5		
IV		1062.7			
A I	0.05	1066.7	1048.2		
II		919.8			
Fe I		5166.3	4375.9(3)	4216.2(2)	3859.9(2)
II	0.02	2600.2(2)	2382.8(3)	2344.2	2260.8(2)
III		1214.6	1207.0	1122.5	

TABLE II

EQUIVALENT WIDTHS OF INTERSTELLAR LINES PRODUCED BY A TYPICAL CLOUD

Element	λ (Å)	Optical Thickness at Center	Position on Curve of Growth	Equivalent Width (Å)
H	1215.7(Lα)	5.0×10^7	Damping	9.4
	923.2(L8)	1.9×10^5	Saturated Doppler	0.063
C II	1334.5	1.3×10^3	Saturated Doppler	0.071
N I	1135.0	6.9×10^3	Damping	0.12
O I	1302.2	2.6×10^4	Damping	0.48
Mg I	2852.1	0.14	Linear	0.007
Mg II	2795.5	1.0×10^4	Damping	0.29
Fe II	2600.2	2.6×10^2	Saturated Doppler	0.12
Na I	5890.0(D2)	2.4	Doppler	0.11

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Stellar Astronomy from a Space Vehicle

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Space research in stellar astronomy will initially concentrate on observations in the vacuum ultraviolet and x-ray region. Future observations will be substantially aided by a series of general sky surveys in the ultraviolet both by rocket flights and satellite observations. This paper describes some of the stellar observations that might prove most profitable in the light of current astrophysical knowledge. The topics discussed fall under the following headings: A. Ultraviolet and infrared survey studies, B. Stellar energy distribution, C. Stellar spectroscopy, D. Interstellar medium, E. Extragalactic studies, and F. High resolution studies.

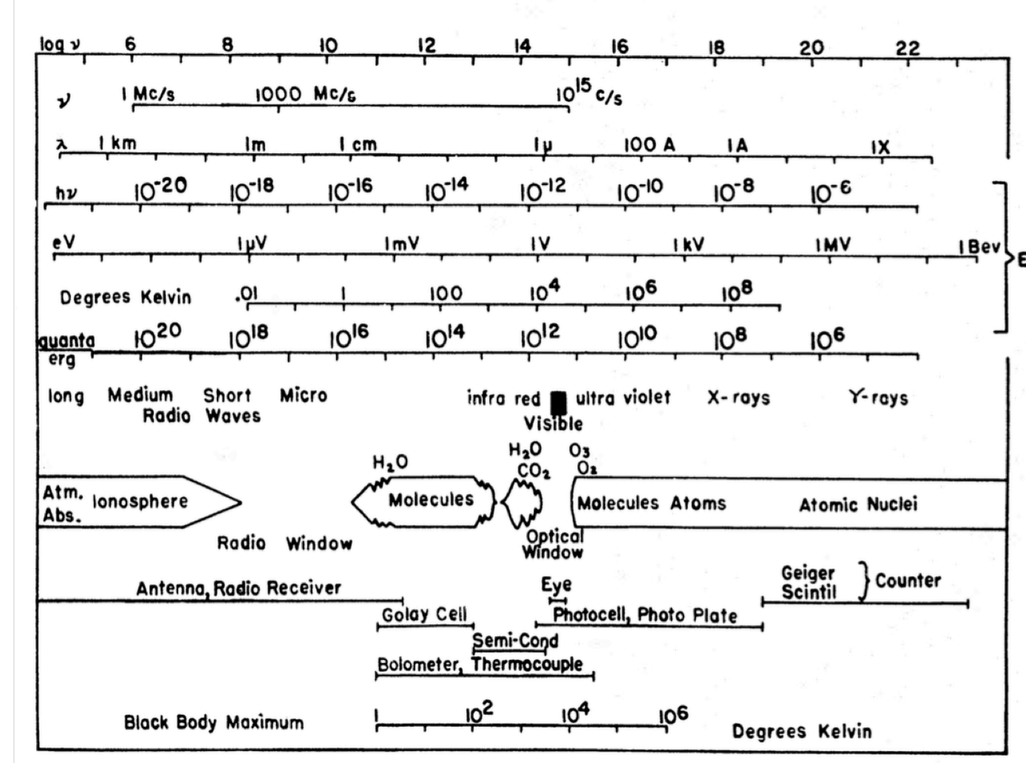

FIG. 1. Relation of energy units and detectors as a function of frequency.

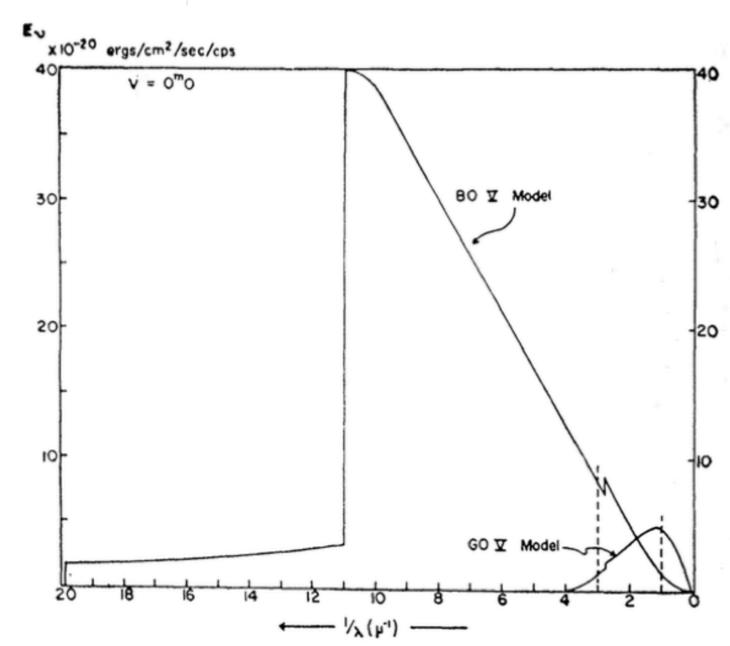

FIG. 3. Far-ultraviolet spectral energy distribution for main sequence B0 and G0 stars.

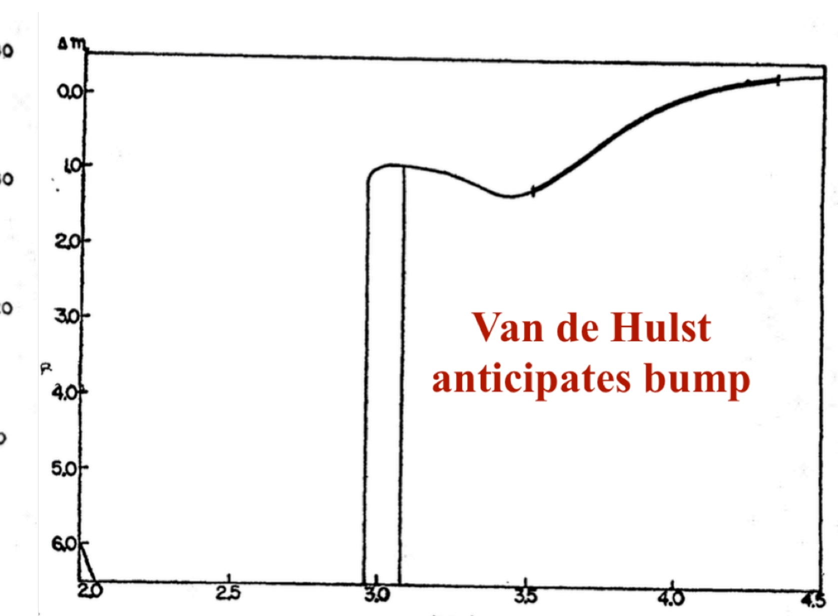

FIG. 5. Ultraviolet extension of interstellar reddening curve.

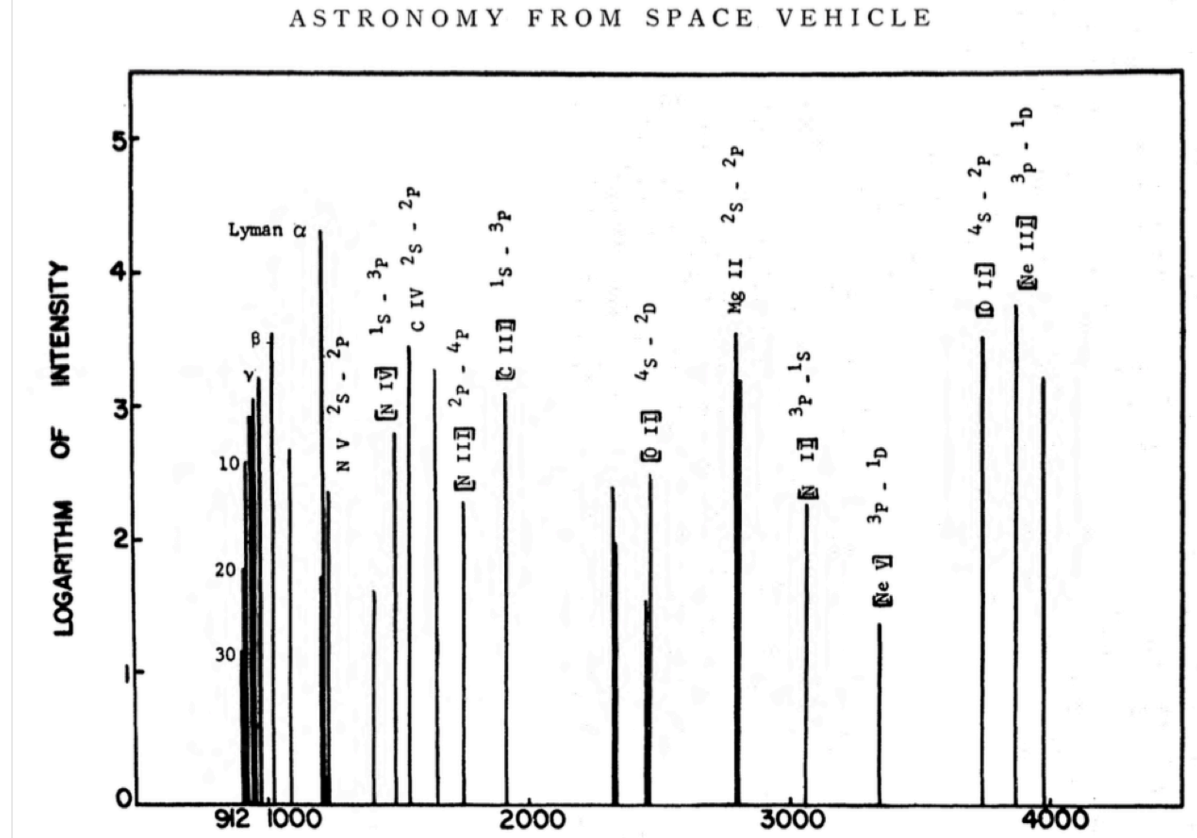

FIG. 7. Expected ultraviolet spectrum of a planetary nebula.

Morton, Spitzer 1966

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LINE SPECTRA OF DELTA AND PI SCORPII IN THE FAR-ULTRAVIOLET

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ABSTRACT

During the past year three Aerobee rockets were launched to obtain stellar ultraviolet line spectra using two objective spectrographs with f/2 Schmidt cameras. One corrector was quartz and the other calcium fluoride. The whole rocket was directed toward the target field by a Space General attitude control system. Limit-cycle jitter parallel to the dispersion was reduced to ±16″ by pivoting the spectrographs in this direction and attaching to them a large gyro rotor gimbaled about a perpendicular direction. Thus fine stabilization in one coordinate was achieved by a purely mechanical system.

On the first two flights the attitude control system failed to stabilize the rocket. On the third flight both coarse and fine systems operated properly, but the parachute failed on re-entry so that the impact damaged the payload beyond repair and admitted light into the film cassettes. Most of the films were totally fogged, but underdeveloping one from the calcium-fluoride camera showed wide spectra of the early B-type stars δ and π Scorpii with a resolution of about 1 Å. The spectra extend from 1260 to 1720 Å for δ Sco and from 1260 to 2180 for π Sco. Many lines are visible in both spectra, all in absorption. Wavelengths are given here for twenty-nine lines, of which twelve are common to both spectra. Identifications include C II λ 1335, Si IV λλ 1394, 1403, C IV λ 1549, He II λ 1640 Å, and probably a number of features due to C III multiplets. The spectra are too weak to permit any useful intensity calibration, but in general they seem to be consistent with the latest models now available for these stars. A number of interstellar features, due to O I at 1302 Å, S II at 1526 Å, and Al II at 1671 Å, are apparently also present, and the C II lines may be partly interstellar.

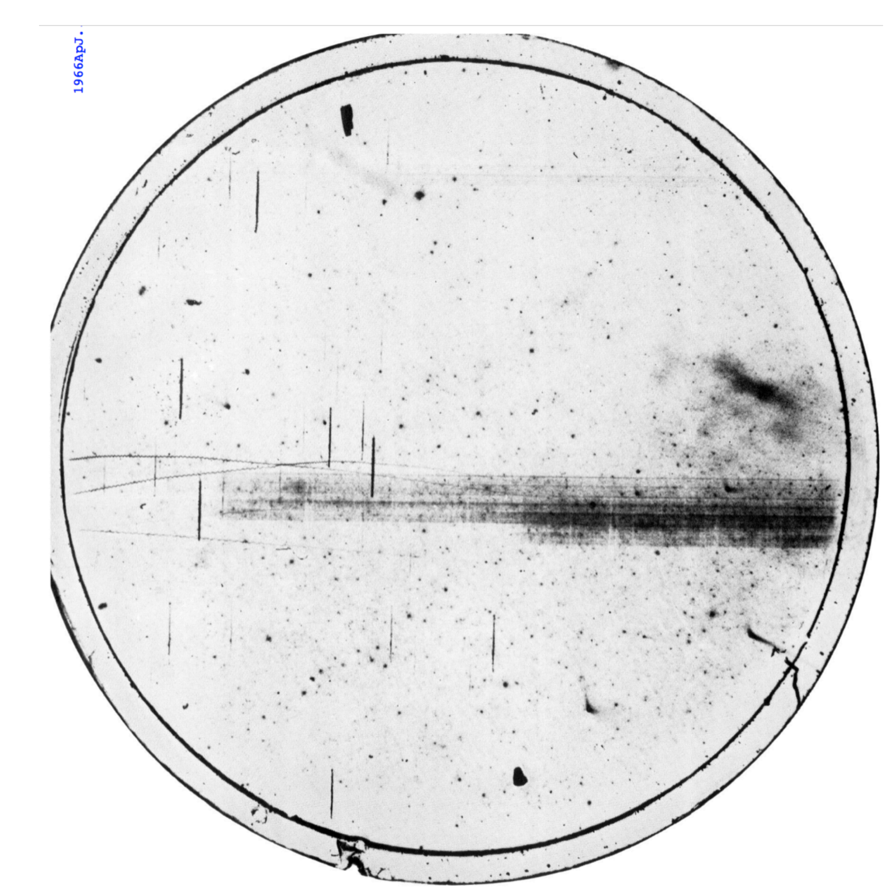

FIG. 3*a*.—Ultraviolet spectra of δ and π Scorpii. The π Scorpii spectrum extends over three-quarters of the diameter, from [illegible] to 2180 Å; that of δ Scorpii over the right-hand third of the diameter, from 1260 to 1720 Å. The vertical lines are zero-er spectra of stars in Libra. The small specks are film imperfections and incipient fogging, greatly enhanced in the reprotion.

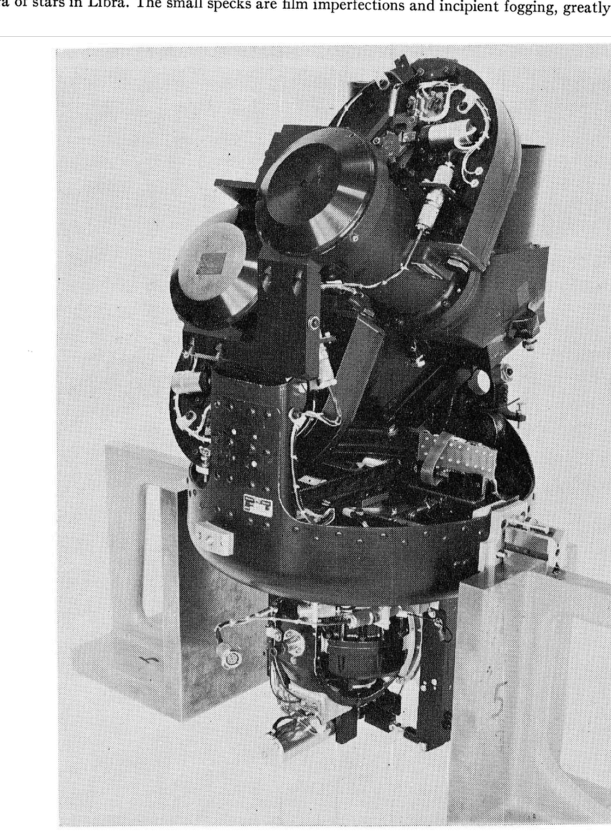

FIG. 1.—Platform assembly with spectrographs and gyroscope. The entire unit was stabilized in the dispersion direction by the gyro. The far camera contained the lithium fluoride corrector on this flight. One bearing of the platform axis is visible resting in a V-block, while lower at right angles is a bearing for the gyro axis. Photo courtesy Perkin-Elmer Corp.