

JOINT DISCUSSION

mirror which reflects the light of the primary image into the enlarging lens was mounted on a rotating arm so that this mirror spent only 3% of the total time in the hot primary image. In the pointing mechanism photo-diodes were used to provide the electric signals to keep the telescope pointed at the Sun with the help of two motors, continuously and fully automatically.

Three balloon flights were carried out last summer, all three at an altitude of 80,000 ft (25 km, air pressure 4% of ground pressure). The first of these flights had the purpose only of testing the pointing mechanism, but in the second and third flight the full telescope was flown. Eight thousand photographs were taken on each of these two flights. Focusing was achieved by scanning the range of focus-uncertainty in twenty consecutive exposures and by continuously repeating this scanning so that unavoidably only a small fraction of all the frames was in good focus.

The best of the photographs of the solar granulation thus obtained are of high definition and show the granulation to have a quite peculiar character; the granulation appears to have a cellular, though highly irregular, structure with the bright elements being separated by narrow dark lines. This type of structure had already been suggested by the best photographs of Leighton on Mount Wilson, by Thiessen's visual observations and by one of the early plates taken by Janssen. The diameters of the bright granules are found to range from about 1500 km down to about 250 km, the latter corresponding to the diffraction limit of the telescope. The existence of the large elements agrees with the observation of perspectival foreshortening near the Sun's limb found by Rösch on Pic-du-Midi. The existence of the very small elements as well as the sharpness of the dark lines agrees with the theoretical expectation that the scale height of the photosphere should present an effective linear scale for the granulation. The root-mean-square intensity fluctuation was found to be about $\pm 5\%$, corresponding to a root-mean-square temperature fluctuation of about $\pm 60^\circ$, in serious discord with the value of $\pm 400^\circ$ previously derived from other indirect data.

The character of the solar granulation shown on these new stratospheric photographs closely simulates that of 'non-stationary convection' earlier studied by Siedentopf in the laboratory; this character is distinctly different from stationary Benard cells on the one extreme and from well-developed turbulence on the other extreme.

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DR J. RÖSCH presented in the form of lantern slides a number of photographs of solar granulation taken at Pic-du-Midi. These photographs demonstrated the high state of the art in ground-based studies of solar granulation.

3. ASTROPHYSICAL MEASUREMENTS FROM ROCKETS

HERBERT FRIEDMAN*

X-RAYS FROM A QUIET SUN

The X-ray spectrum of a quiet Sun can be approximated by a $500,000^\circ$ K Planckian distribution. In the absence of coronal excitation, as evidenced by the intensity of the Fe XIV green line, the X-ray spectrum has a short wave-length limit near 20 \AA . Coronal activity is accompanied by weak emissions down to wave-lengths as short as 6 \AA , which appear to be associated with coronal hot spots at temperatures of $2 \times 10^6^\circ$ K or higher. One may draw the conclusion that rocket data support a picture of localized hot condensations

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PLATE IV

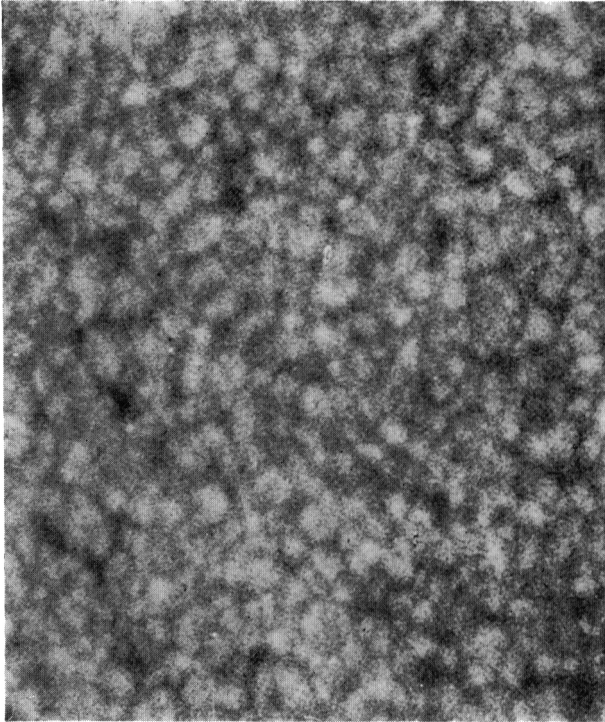


Image de la granulation solaire au centre de disque obtenue en ballon à 6000 m. d'altitude. Champ = 50" × 60". Réfracteur de 30 cm. Filtre vert (A. Dollfus et D. E. Blackwell).

SATELLITES, ROCKETS, BALLOONS

of transient character spread over a base of cooler coronal gas covering the entire disk. Maximum and minimum values of the X-ray flux over one solar cycle were 0.13 and 1.0 erg cm⁻² s⁻¹.

SOLAR LYMAN ALPHA

In the solar spectrum between 1050 Å and 1350 Å, the Lyman- α line is by far the most prominent feature. Approximately 90% of the total intensity in this band of wavelengths is contained in this one line. Since 1949, fourteen measurements of the intensity of Lyman- α have been published. From 1950 to 1954 the intensities fell in the range from 0.1 to 1.6 ergs cm⁻² s⁻¹. An improved ionization chamber technique was introduced in 1955 and seven measurements between then and 1958 all fall close to 6 ergs cm⁻² s⁻¹. In view of the consistency of the ion chamber results it would be wise to wait for observations of the declining phase of the current solar cycle before concluding that Lyman- α shows a large variation.

X-RAY EMISSION OF SOLAR FLARES

In 1957, as part of the I.G.Y. program, the U.S. Naval Research Laboratory continued its studies of flares with ground-launched two-stage solid propellant rockets. Data were obtained on Class 1+, 2 and 3 flares. In each case strong X-ray emission was observed but no evidence for large increases in Lyman- α . It is possible that Lyman- α could have flashed earlier in the flare process than the times of firings of the rockets. In each launching an attempt was made to time the rocket firing to coincide with the maximum phase of the flare, so that the first few minutes of flare development were always by-passed. The X-ray emission below 8 Å exceeded 0.02 erg cm⁻² s⁻¹ in the class 2 flare. In the class 3 flare, the maximum depth of penetration was 63.5 km, from which it could be deduced that the X-ray spectrum extended to wave-lengths as short as one or two angstroms.

LYMAN- α RADIATION IN THE NIGHT SKY

Ionization chambers sensitive to Lyman- α were flown in an Aerobee rocket to a height of 146 km at night at 2156 M.S.T. 1957 March 28. At an altitude of 75 km an intense glow, diffused over the entire sky, was seen above the rocket. At 85 km, an additional source became evident, originating in the atmosphere below the rocket. Both fluxes increased up to 120 km and then remained constant to the peak of the flight, 146 km. Both the atmospheric and extra-terrestrial sources of radiation can be identified with the Lyman- α emission of hydrogen. Furthermore, this radiation appears to be of solar origin. The flux from outside the atmosphere is scattered by atomic hydrogen in space; the flux from below the rocket is scattered a second time by hydrogen in our atmosphere. The observed albedo was about 42%. The flux of Lyman- α at night at the top of the Earth's atmosphere is 10⁻² erg cm⁻² s⁻¹ from the entire hemisphere.

Estimating the neutral hydrogen density of interplanetary space from these observations is complicated by our lack of detailed knowledge of factors such as the solar line profile and particularly its central intensity. From the mere fact that the distribution shows a minimum in the anti-solar direction when viewed from the Earth it is possible to conclude that the upper limit of neutral hydrogen density is about one atom per cm³.

ROCKET ASTRONOMY IN THE FAR ULTRA-VIOLET

Far ultra-violet radiation of galactic origin was first discovered in a rocket flight in November 1955, but the optical resolution of the detectors was not sharp enough to permit any detailed mapping of the sources. The experiment was repeated on the night of 1957 March 28 with much higher resolution. In the wave-length interval from 1225 Å to 1350 Å numerous extended sources of gaseous nebulae were mapped out with a resolution of 3°.

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These sources were characterized by high surface brightness ($\sim 10^{-3}$ erg cm $^{-2}$ s $^{-1}$ per steradian).

The experimental data permitted the plotting of contour maps of intensities in the wave-length interval 1225 Å to 1350 Å. Seven strong emission nebulosities were mapped. These fell in the regions of:

- | | |
|----------------|------------------|
| 1. Orion | 5. Leo |
| 2. Taurus | 6. Virgo (Spica) |
| 3. Canis Major | 7. Ursa Major |
| 4. Puppis-Vela | |

The nebulosities around α Virginis and Orion were scanned so many times that detailed contour maps could be drawn. The nebula around α Virginis is over 20° in diameter. There is no visible nebulosity in this region. The Orion nebulosity is very extensive, 25° × 30°, and is not restricted to the H II regions observed in visible light. The ultra-violet radiation correlates roughly with the distribution of inter-stellar material in Orion and has a surface brightness comparable to that of the discrete emission nebulosities in H α . But the area of ultra-violet nebulosity is much larger so that the total energy radiated in the narrow spectral band 1225 Å–1350 Å must be extremely high. Table 1 lists the emission features of the two nebulae.

Table 1. *Emission characteristics of ultra-violet nebulae (1225 Å–1350 Å)*

	α Virginis (Spica)	Orion
Surface brightness, erg cm $^{-2}$ s $^{-1}$	3×10^{-4}	6×10^{-4}
Flux at Earth, erg cm $^{-2}$ s $^{-1}$	1×10^{-5}	5×10^{-5}
Distance from Earth	87 parsecs	400 parsecs
Total energy ergs s $^{-1}$	10^{37}	10^{39}
Average volume emissivity erg cm $^{-3}$ s $^{-1}$	2×10^{-22}	5×10^{24}

4. THE EXTREME ULTRA-VIOLET SPECTRUM OF THE SUN

R. TOUSEY

The study of the extreme ultra-violet spectrum of the Sun commenced in 1946 in the United States. The institutions now involved are the U.S. Naval Research Laboratory, the Air Force Cambridge Research Center, and the University of Colorado. The overall program has many objectives. From the point of view of astrophysics the objective is to uncover the solar spectrum to the very shortest wave-lengths. Resolution should be sufficient to identify all the Fraunhofer lines. The intensity distribution must be measured through the entire continuum. As many as possible of the emission lines should be photographed and their intensities and profiles determined. The variation of intensity over the disk and effects connected with flares should be investigated for the important lines.

The intensity distribution in the continuum has been measured by the Naval Research Laboratory; preliminary data were reported by Johnson, Purcell, Tousey and Wilson^[1] to 2200 Å. The results of a more recent experiment show that these data were somewhat low at wave-lengths below 2400 Å, and that the intensity rises to the 5200° K level at 2200 Å.

The region 3000 Å to 2085 Å is a continuum with Fraunhofer lines similar to the near ultra-violet and visible. Its most interesting feature is the doublet of Mg II at 2795 Å and 2803 Å, corresponding to the H and K lines of Ca II. In September 1957, N.R.L. flew a high resolution spectrograph in an attempt to obtain the profile of the Mg II lines, as well as to resolve more of the Fraunhofer lines. The instrument employed an echelle grating ruled with 80 lines per mm, in orders ranging from 75 at 3000 Å to 112 at 2000 Å. The