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

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 Hα. 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^{-23}	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 laboratory resolution was 0·04 Å, but in flight the resolution was 0·1 Å. A spectrum was obtained that shows, in addition to the wide absorption lines and the emission line cores, absorption lines cutting into the peaks of the emission lines. These absorption lines correspond to the H_3 and K_3 lines of calcium. The half-widths of the second components were approximately 0·4 Å. The third components were displaced from the second by about 0·05 Å to long wave-lengths. Compared to the H_2 and K_2 lines of Ca II the corresponding Mg II emission is much more intense. The reasons are that there is more ionized Mg and Ca at high levels in the solar atmosphere, and that the continuum is less intense at 2800 Å than at 3934 Å. The displacement between the third and second components is less for Ca than for Mg.

A striking change takes place in the nature of the spectrum at 2085 Å. Below this wave-length the intensity of the continuum becomes suddenly less, and the Fraunhofer lines become faint. The change is attributed to a sudden increase in the opacity of the solar atmosphere. Below 2085 Å the radiation comes from a higher level, where the temperature is lower. The most probable explanation, advanced by Goldberg [2], is that the sudden change is produced by quasi-continuous absorption by molecules composed of the most abundant elements in the solar atmosphere. The most likely molecules are NO and CO.

The wave-length range 2000 Å to 1500 Å covers the region where the solar spectrum changes from a continuum with Fraunhofer lines to a spectrum of emission lines above an ever-decreasing continuum. A spectrum of this region was obtained by N.R.L. in 1955 and has been published by Johnson, Malitson, Purcell and Tousey [3]. Approximately 45 emission lines were present. The continuum could be followed to 1550 Å. It is difficult to analyse the detail in the continuum because gaps between Fraunhofer lines closely resemble emission lines, at the present resolution.

Many lines in the 1955 N.R.L. spectrum have been confirmed and a few additional lines have been found in spectra obtained subsequently by N.R.L. and by the University of Colorado. The line of longest wave-length is at 2006 Å and the next is at 1892 Å. Neither has been identified. The line of shortest wave-length was the 977 Å resonance line of C III. Within this range nearly all the raies ultimes and strongest resonance lines of the most abundant elements in the Sun were found. These include lines of H (Lyman α and β); He II (1640 Å); C I, II, III, and IV; NV; O I and VI; Si II, III, and IV; S II; and P II. Not found were the triplet of N I containing the raie ultime at 1135·0 Å, the multiplet of N II with the raie ultime at 1085·7 Å, and the resonance line of N III at 991·6 Å. A prominent line at 1670·8 Å was tentatively ascribed to the raie ultime of Al II, although there was a possibility that it is blended with a line of Fe II.

Recently a spectrum extending to much shorter wave-lengths was obtained by Rense [4], and associates at the University of Colorado. The most conspicuous new feature of the spectrum was the He II raie ultime at 303·8 Å. This was present with considerable intensity and was photographed in three orders. The He I raie ultime, 584·3 Å, was also present, but was rather weak, perhaps partly because of atmospheric absorption, which is strong at this wave-length. The instrument was a grazing incidence spectrograph, flown to a peak altitude of 210 km on 1958 June 4.

Work is continuing on the width of the Lyman-α line. At present the width is controversial. Behring, McAllister and Rense [5] have concluded that the line is at least 0·8 Å wide, at half maximum; the N.R.L. work [3], on the other hand, seems to indicate a width not greater than 0·3 Å.

Considerable effort has been spent in attempts to photograph the Sun in the light of the Lyman-α line. Mercure, Miller, Rense and Stuart [6] obtained four faint disk images in 1956. The structure, although in part ascribable to granularity, was found to correlate with plage areas present in Hα and K line photographs taken from the ground on the same day. Additional evidence that plage areas emit Lyman-α strongly is furnished by spectra obtained by N.R.L. in 1958.

Some qualitative indications have been found that certain of the emission lines are limb brightened. In a stigmatic spectrum obtained by N.R.L. in May 1957, the resonance lines of C IV (1548·2, 1550·8 Å), show considerable brightening at their ends, while the nearby C I multiplet at 1560 Å does not. The He II line at 1640·5 Å shows some limb brightening compared to the C I multiplet near 1657 Å. The same was observed in the 1955 spectrum, but not as clearly. In the 1955 spectrum the O VI resonance line 1031·9 Å is definitely limb-brightened by comparison to Lyman-β at 1025·7 Å. This would, of course, be expected for a line that must originate in the top of the chromosphere, or bottom of the corona.

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5. STUDY OF COSMIC RAYS BY ROCKETS AND SPUTNIKS IN THE U.S.S.R.

S. N. VERNOV AND A. E. CHUDAKOV

In the U.S.S.R. the study of cosmic rays by rockets was started in 1947.

In the beginning, with the help of Geiger counters the number of charged particles was measured, and the formation of the electron-photon component in the interaction of primary particles of cosmic rays with nuclei of light elements was investigated.

It was shown that in 1947, 1948, 1949 and 1951 the intensity of cosmic rays at altitudes up to 75 km was the same and did not change more than by 5%. In 1949 the data on the photon intensities outside the atmosphere were obtained. In order to measure the number of high-energy photons, one of us (A. E. Chudakov) proposed a method permitting these measurements to be made with a strong background of charged particles.

It was found, with the help of this apparatus, that at altitudes exceeding 50 km, the flux of photons with energy of the order of 10^7 eV and more is 0·25 photons/cm^{-2} sec. The same apparatus was used for measuring photons in the stratosphere at various heights, and it was shown that at the heights of 20 km, a maximum intensity is 0·7 photons/cm^{-2} sec.

Ionization produced by cosmic rays up to altitudes of 100 km was measured in 1951. Measurements were carried out with absorbers of various thicknesses: 1 g/cm^2 of steel, 15 cm of aluminium, 1 cm of lead.

Surrounding the ionization chamber with lead 1 cm thick leads to an increase of ionization by a factor of 2·06 ± 0·003; with 15 cm of aluminium the increase is 1·92 ± 0·02; and with 15 cm of aluminium and 1 cm of lead the increase is 3·26 ± 0·03. The difference in the values of ionization obtained during three rocket flights does not exceed 2 or 3%.

Comparison of ionization and the number of particles in the stratosphere with those above the atmosphere shows that an average specific ionization of cosmic ray particles considerably exceeds ionization of the relativistic particle.

Relation of the average specific ionization to ionization of the relativistic particle is as follows:

20 km	– 1·59 ± 0·06	Without absorber
50 km	– 2·16 ± 0·07	
50 km	– 1·68 ± 0·06	Under the layer of aluminium 15 cm thick.

The high value of the specific ionization in the stratosphere can be explained by the existence of secondary heavy (sufficiently slow) particles.