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ON SOME SOLAR AND LUNAR SPECTRA TAKEN IN LITTLE AMERICA, ANTARCTICA*

By Malcolm P. Hanson** and E. O. Hulburt
Naval Research Laboratory

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Abstract

Solar spectra were taken with a small quartz spectrograph at noon on November 13, 1929, and January 25, 1930, in Little America, Antarctica, by Malcolm P. Hanson of the Byrd Antarctic Expedition. The ultraviolet limit of these spectra was at about 304$\mu\mu$ which was the same as the ultraviolet limit of noon solar spectra taken at Washington, D.C., in December and January. Assuming that the ultraviolet limit of the solar spectra was due to ozone in the upper atmosphere and that the amount of ozone in Washington was the same as that measured by Dobson, Harrison, and Lawrence at Oxford, England, it came out that the effective thickness of the ozone at N.T.P. above Little America was about 0.28 cm on November 13, 1929, and January 25, 1930.

The ultraviolet limit of lunar spectra taken at Little America on April 24, 1929, two days after the Antarctic winter night set in, and on July 18, 1929, thirty-five days before the night ended, was at about 305$\mu\mu$.

AMID the stress of final preparations for the departure of the Byrd Antarctic Expedition it was decided to take along a small quartz spectrograph, Hilger, Type E3. An experiment was hurriedly planned which consisted simply in photographing spectra of the sun and the moon in Antarctica with exposures long enough to bring out the ultraviolet region around 300$\mu\mu$. Meanwhile similar spectra were made with a similar spectrograph at the Naval Research Laboratory, Washington, D.C. By a comparison of the two sets of spectra it was hoped to learn something about the ozone in the upper atmosphere of Antarctica. The dispersion of the spectrographs was about 4$\mu\mu$ per mm at wave-length 300$\mu\mu$.

November 13, 1929, was clear and solar spectra were obtained at Little America, latitude 78.6° south, with a slit width of about 0.02 mm, being purposely over-exposed in the visible part of the spectrum in order to bring out the ultraviolet end. The ultraviolet limit of spectra taken at noon, local time, was at about 304$\mu\mu$. The same limit was given by similar spectra at noon on January 25, 1930. The midnight sun spectrum of January 25, 1930, ended at about 320$\mu\mu$; the sun was about 9° above the horizon at that time.

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** In charge of radio of the Byrd Antarctic Expedition.

The noon solar spectra at the Naval Research Laboratory for November and December, 1929, and January, 1930, ended at about 303, 304 and 304$\mu\mu$, respectively; the same values were found, respectively, for November and December, 1930, and January, 1931. The noon spectra for June, 1930, ended at about 299$\mu\mu$. It is seen that the solar ultraviolet limit was the same on November 13, 1929, and January 25, 1930, at Little America as it was in December or January at Washington. The altitude of the sun was approximately the same at the two places, being about 30° from the horizon at Little America and 27° to 30° at Washington. Therefore, since the ultraviolet end of the solar spectrum is limited by the ozone in the upper atmosphere the measurements indicated that the ozone in November, 1929, and January, 1930, was of about the same thickness in Little America as it was in Washington in December and January. It is due to the fortunate circumstance that both the elevations of the sun and the ultraviolet solar spectrum limits were about the same at Little America and at Washington that one can say that the ozone thicknesses were the same at the two places. If, for example, the spectrum limits had been the same and the solar elevations different, or vice versa, the program of observations could probably not have been used with safety to derive an exact conclusion about the relative amounts of ozone in the two regions.

We do not know what the thickness of the ozone was in Washington but we may assume it to be roughly the same as that in Oxford, England, observed by Dobson, Harrison, and Lawrence[1] in 1925 and 1926. The justification of this assumption is found in the fact that the seasonal variation, with the maximum in August, of the intensity of the therapeutic solar wave-lengths 290 to 310$\mu\mu$, observed by Clark,[2] in 1927 and 1928 in Baltimore, Md., U.S.A., agreed fairly well with the intensity calculated[2] from the ozone absorption coefficients of Fabry and Buisson,[3] the 1925 and 1926 ozone thickness[1] at Oxford and the solar zenith distance at Baltimore. Clark's[4] further observations showed that the curve of the seasonal variation of the solar radiations from 290 to 310$\mu\mu$ was approximately the same in the years 1929 and 1930 as it was in the years 1927 and 1928.

Interpolating among the Oxford measurements (ref. 1, Table 3) gives the values for December and January to be 0.27 and 0.29 cm of ozone, respectively. Accordingly, the average of these, or 0.28 cm was the value of the effective thickness of the ozone in Little America on November 13, 1929, and January 25, 1930. It need hardly be said that the present method of determining ozone by means of the ultraviolet limit of the solar spectrum can not be depended upon to give great accuracy. It is to be hoped that future polar expeditions may be equipped to carry out much better determinations of ozone.

The value 0.28 cm of ozone in midsummer at Little America is in keeping

[1] Dobson, Harrison and Lawrence, Proc. Roy. Soc. **A114**, 521 (1927).
[2] Clark, Amer. Jr. Hygiene **9**, 646 (1929).
[3] Fabry and Buisson, Journ. de Phys. **3**, 196 (1913).
[4] Clark, Amer. Jr. Hygiene **12**, 690 (1930).

with the probable average values in north polar regions in midsummer, namely, 0.290 cm for July and 0.265 for August, estimated by Dobson.[5] Dobson[1,5] concluded that the ozone values found by various stations scattered over the earth would be most simply accounted for by the hypothesis that corpuscular radiation from the sun is "the chief ozone forming agent at the poles and possibly for the rest of the world" (ref. 5, page 431). We do not think that the observations call for any such extreme hypothesis. Maris'[6] calculations of the temperatures of the high atmosphere indicate wind movements in the high atmosphere which, combined with the hypothesis that ozone is formed by certain wave-lengths of the ultraviolet portion of the solar spectrum and is decomposed by other wave-lengths, would lead, qualitatively at any rate, to an ozone distribution in agreement with observation. One cannot make an exact calculation of the matter for the photochemical quantum efficiencies of the formation and destruction of ozone by the various ultraviolet wave-lengths are not yet known.

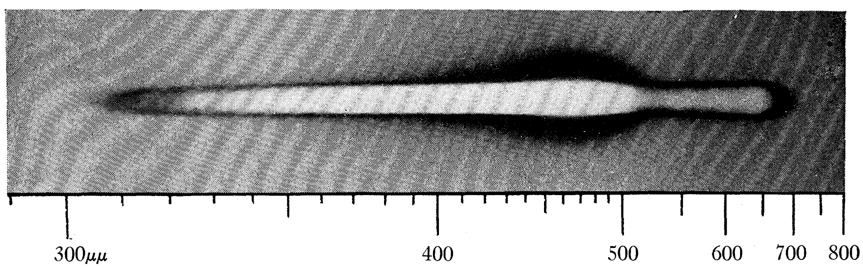

Fig. 1. Spectrum of the moon taken at Little America on July 18, 1929.

Spectra of the moon were taken at Little America on April 24, 1929, and on July 18, 1929. It will be remembered that the sun's last official appearance at Little America was on April 22 and his official reappearance was on August 22. Thus the moon spectrum of April 24 was obtained two days after the beginning of the Antarctic winter night and the one of July 18 was obtained thirty-five days before the end of the Antarctic night. The spectrograph was mounted outside on the snow, aimed at the moon and shifted by hand from time to time. The moon was focussed on the slit by a quartz lens 5 cm in diameter and 20 cm in focal length. The spectra of April 24 were taken with a slit width of 0.3 mm and exposures from 1 to 15 minutes. With such a wide slit the ultraviolet limit of the spectrum was not sharply defined, and the only safe conclusion that could be drawn was that the ultraviolet limit was between 310 and 300$\mu\mu$.

On July 18 the moon was about 40° from the horizon and the temperature was $-50°$ Farenheit. A good spectrum, reproduced as a positive in Fig. 1, was obtained with an exposure of one hour at midnight, local time, and a slit width of 0.05 mm. Eastman Commercial Panchromatic cut film was

[5] Dobson, Proc. Roy. Soc. **A129,** 412 (1930).

[6] Maris, Terr. Mag. and Atmos. Elec. **33,** 233, (1928); **34,** 45 (1929).

used. The spectrum extended to about 305$\mu\mu$, the last solar absorption line being at this wave-length. It is doubtful whether the solar absorption lines, which are clear enough on the original negative, can be seen in the reproduction of Fig. 1.

The film was somewhat fogged throughout and the bright lunar spectrum of Fig. 1 is seen to be surrounded by a region relatively darker than the general fogged field. The dark halo around the spectrum is thought to be due to the Eberhard photographic effect. If a plate or film be uniformly exposed to light of moderate intensity and if a small area be then given an additional heavy exposure, on development a region of abnormally lowered density will be noted around the dense portion. This is caused by the large quantity of soluble bromide thrown off from the heavily exposed area of emulsion during the development which acts as a restrainer and slows up the development of the surrounding regions. It is not known whether the low temperature during the exposure had anything to do with the rather unusual appearance of the negative of Fig. 1. The development of the film, which was done about three days after the exposure, was effected under approximately normal conditions. The solar spectra and the moon spectra of April 22, as well as the Washington spectra, in general showed the Eberhard effect to a slight degree, but none to the extent of the negative of Fig. 1.

Since the lunar spectra ended at about 305$\mu\mu$ it is concluded that the ozone in the high atmosphere of Little America during the winter night was not greatly different from ozone in other parts of the world. Rosseland[7] also found that stellar spectra photographed in midwinter at 71° north latitude ended around 300$\mu\mu$.

In conclusion it is a pleasure to mention the assistance of Mr. R. B. Carleton in taking the long series of solar spectra at this laboratory.

[7] Rosseland, Nature **123**, 207 (1929), discussed by Wood on page 644 and by Dobson on page 712.

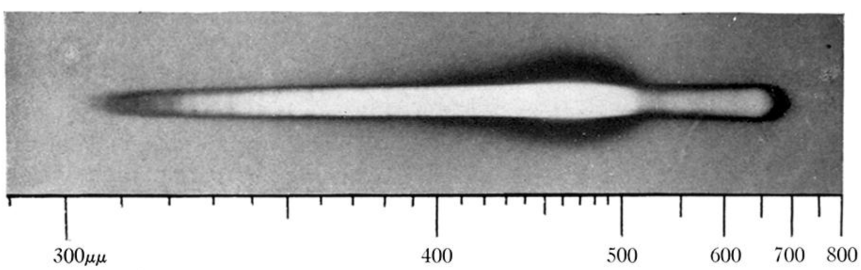

Fig. 1. Spectrum of the moon taken at Little America on July 18, 1929.