VARIATION OF ULTRA-VIOLET RADIATION WITH DUST CONCENTRATION

Thesis

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Publications

The results obtained in this thesis were published in :

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2- The University College for Girls Annual Review No. 4, July 1964, P. 11-16 .

ABSTRACT

Measurements of the total solar radiation at normal incidence and its spectral distribution have been undertaken for clear sky conditions at Giza from March 1961 to February 1962. A Linke - Feussner actinometer No. 113, provided with two Standard Schott Filters OG_1 and RG_2, is used.

As the principal aim of this thesis is to study the effect of suspended dust particles in the atmosphere upon the incoming short wave solar radiation (ultra-violet), a lead oxide filter which permits the measurements of short wave radiation $\lambda \leqslant 425$ mμ has been also used with the two Schott filters. At the same time Millipore filters have been used for dust sampling.

The received solar radiation for the bands $\lambda \leqslant 425$ mμ, $\lambda < 525$, $525 \leqslant \lambda < 630$ and $\lambda \geqslant 630$ mμ, have been studied as function of the air mass as well as their duirnal and seasonal variations. The effect of suspended dust particles in the surface layers of the atmosphere upon the short wave radiation below 425 mμ have been discussed.

It was thus possible to construct a diagram from which the sunny hours richer in the short wave radiation can be calculated. A case was then considered, when the atmosphere was highly polluted with dust, in order to show how effective

these aerosols are upon cutting down the amount and exposure hours of the curative natural short wave radiation.

INTRODUCTION.

Measurements of the total solar radiation at normal incidence were undertaken at Helwan Observatory during the period from 1914 to 1923. Owing to the importance of the study of radiation measurements in biology, architecture and agriculture; a recent program of research has been started in Egypt concerning the study of solar radiation incident on horizontal surfaces, as well as on differently oriented ones. At the same time the spectral distribution of solar energy, with special reference to the short wave region, has been taken into consideration. This thesis is mainly concerned with the short wave solar radiation and its variation with the dust concentration. Evidently in this part of the solar spectrum, the suspended particles in the atmosphere may have a more or less marked influence, while the water vapour does not play any important role.

The short wave radiation near the ultra-violet are responsible for the production of vitamin D in the human body. Its lack will give rise to general ill-health, high incidence of tuberculosis, rickets in children,,...etc, (Meethan, 1956), also its excess causes the increase in frequency and severity of the eye and skin burns. (Blum, 1940-45, Köller, 1952).

Chapter

SOLAR RADIATION

1.1 The Sun:

The sun is, no doubt, the ultimate source of all energy on the earth as it is responsible both directly and indirectly for sustaining life over its surface. It is a large hot gaseous mass, located about ninety-three million miles from the earth, and has a diameter of about hundred and nine times that of the earth (Mc Crea, 1950).

The origin of radiation in the sun takes place in a small core in which energy is produced by molecular processes. The density in the core, which is of the order of 100, decreases outwards. The brilliant round disk of the sun which emits light and heat, and which when viewed through a smoked glass appears as a smooth circular disk, is called the "Photosphere". When examined with the aid of more refined techniques, the photospheric surface appears highly granulated and surrounded by a gaseous envelope. It is almost one thousand kilometer thick; its central distance is about seven hundred thousands kilometers and is called the solar radius. The density falls rapidly outwards in the photosphere, and that is why it has a sharp edge. The surface of the photosphere has a temperature of about six-thousand degrees absolute, while the temperature within its interior rapidly rises to many millions of degrees. It gives rise essentially to continuous spectrum which is interrupted by several thousands of dark absorption lines, the Fraunhofer lines.

Just outside the photosphere, there is a relatively thin "Reversing Layer". It has been given this name because the spectral lines, ordinarily seen as dark absorption lines in the photospheric spectrum, appear as bright emission lines.

Overlying the brilliant surface of the photosphere, there is a shell composed chiefly of hydrogen gas and calcium vapour. This shell is brilliant red in colour and is called the "Chromosphere" or colour sphere. In this chromosphere, huge bursts of hydrogen gas are frequently observed. These bursts are about ten-thousand miles thick, and sometimes attaining heights of one hundred thousand miles or more within very few minutes. It gives rise to flash spectrum of emission lines.

Beyond the chromosphere, is the "Corona", (Abettl, 1938) which gives a peculiar mysterious variable light. It consists of highly ionized atoms of rarified gases, and has a temperature of about one million degrees absolute. It gives rise to continuous scattered spectrum with few emission lines.

The sun has two motions. In the first motion, it rot-ates about its axis as does the earth, but it takes about a month for one rotation instead of the twenty-four hours taken by the earth. It rotates more slowly at points far north and far south than it does in lower solar latitudes, causing the disturbances in the sun's atmosphere that give rise to sunspots. The sun, in its other motion, moves through space among the neighbouring stars at a speed of about forty-thousand miles per hour.

The photosphere, which is the principal source of energetic radiation in the sun, is considered as a black body whose equivalent temperature is taken as 6000 degrees absolute. The radiation emitted from the sun, is of the short wave type. The spectral distribution of the solar radiation outside the earth's atmosphere is given in table 1 (Allen, 1958).

Table [illegible]

Solar Radiation [illegible] Outside the Earth's Atmosphere

Visible spectrum, etc.

λ (μ)	f_λ (erg cm^{-2} $\mathring{A}^{-1}$ sec^{-1})	log f % (in erg cm^{-2} sec^{-1})
0.20	0.5	1.0
0.22	3.0	1.82
0.24	6	2.16
0.26	12	2.49
0.28	24	2.85
0.30	55	3.22
0.32	75	3.38
0.34	97	3.52
0.35	105	3.57
0.36	109	3.59
0.37	112	3.62
0.38	115	3.64
0.39	123	3.68
0.40	153	3.79
0.41	176	3.86
0.42	186	3.89
0.44	203	3.950
0.46	215	3.995
0.48	214	4.012
0.50	206	4.015
0.55	195	4.030
0.60	183	4.041
0.65	164	4.027
0.70	146	4.009
0.75	128	3.982
0.80	113	3.957
0.9	89	3.90
1.0	72	3.86
1.1	59.5	3.82
1.2	49	3.77
1.4	32.5	3.66
1.6	22.3	3.55
1.8	15.2	3.44
2.0	10.8	3.33
2.5	4.97	3.09
3	2.63	2.90
4	0.93	2.57
5	0.41	2.31
6	0.21	2.10
7	0.12	1.92
10	0.023	1.36

Radio spectrum

λ (cm)	f_λ (erg cm^{-2} sec^{-1})	log f % (in erg cm^{-2} sec^{-1})
0.6	2.8×10^{-5}	- 6.77
1.5	1.1×10^{-6}	- 7.78
3	9.7×10^{-8}	- 8.54
6	1.1×10^{-8}	- 9.18
15	7.7×10^{-10}	- 9.94
30	1.1×10^{-10}	-10.48
60	1.8×10^{-11}	-10.97
150	9.1×10^{-13}	-11.87
300	6.0×10^{-14}	-12.74
600	4.2×10^{-15}	-13.60

X-ray spectrum, etc.

λ $\mathring{A}$	f_λ (10^{-5}erg cm^{-2} $\mathring{A}^{-1}$ sec^{-1})	log f % (in erg cm^{-2} sec^{-1})	log f % (in erg cm^{-2} sec^{-1})
10	4	- 5.4	- 5.4
20	23	- 4.3	- 4.5
50	110	- 3.3	- 3.8
70	120	- 3.1	- 3.7
100	70	- 3.2	- 3.8
200	11	- 3.7	- 3.8
300	10	- 3.5	- 4.4
500	8	- 3.4	- 4.4
700	10	- 3.2	- 3.8
800	20	- 2.8	- 3.0
900	60	- 2.3	- 2.3
1000	40	- 2.4	- 2.8
1100	90	- 2.0	- 3.0
1200	280	- 1.5	- 2.8
1400	540	- 1.1	- 1.6
1600	1600	- 0.6	- 0.7
1800	10000	+ 0.2	
2000	50000	+ 1.0	

1.2 Solar Constant:

The amount of radiation received at the outer limit of the earth's atmosphere, does not change appreciably from year to year; but varies only with latitude and time of the year. A measure of this amount is the "Solar Constant" which is defined as the solar energy which reaches the outer limit of the atmosphere and is received in one minute by an area of one square centimeter placed perpendicular to the sun's rays and at the mean distance between the sun and the earth. The most recent data available (Johnson,1954) shows that the solar constant has the value 2.00 ± 0.04 cal/cm^2/min or about 440 B.T.U. per square foot per hour.

X-rays and other radiations of very short wavelengths in the extreme ultra-violet part of the solar radiation (0.12 to 0.18 μ) are absorbed by oxygen and nitrogen atoms in the ionosphere at heights greater than 100 kilometers above the earth's surface (Ramdas,1956). Furthermore, due to the concentration of ozone at elevations between 15-35 kilometers, somewhat longer wavelengths are absorbed. Therefore, it is found that solar spectrum received at the earth's surface is cut off below 0.29 microns.

1.3 Atmospheric Scattering:

The direct radiation from the sun is attenuated by the scattering effect of the molecules of nitrogen, oxygen, and other constituents of the atmosphere. Since the molecular size is very small compared with the wavelengths under consideration, the Rayleigh fourth-power relation should apply. That this relation applies was shown by (Fowle,1918), who was able to obtain a fairly precise determination of Loschmidt's number by substituting, in Rayleigh's formula, atmospheric transmission data obtained on Mount Wilson.

The study of a large number of data allowed (Fowle, 1914) to separate the scattering effect of water vapour from the true atmospheric scattering. The transmission factor of the atmosphere directly above Mount Wilson and with no water vapour may be written :

$$\tau_{a_\lambda} = 10^{-k_{a_\lambda}} \qquad (1)$$

where k_{a_λ} is a function of the wavelength. The values of k_{a_λ}, obtained from the experimental values of τ_{a_λ}, are plotted against the wavelength (Moon, 1940). Fowle found that between 0.35 and 0.50 μ, the results can be represented by a straight line having a slope of − 4, as would be expected from Rayleigh's theory. The data, for wavelengths from 0.5 to 0.7 μ, depart from the straight line because of the Chappuis ozone band. The transmission factor for wavelengths greater than 1 μ, is very close to unity, and the experimental errors make the points completely unreliable. There is no doubt to believe, however, that the Rayleigh relation