ON THE DISTRIBUTION OF ULTRA-VIOLET INTENSITY IN THE SUN-LIGHT AT CALCUTTA DURING THE YEAR 1931-32.*

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Introduction.

It is well known that the solar spectrum, though continuous and extending from ultra-violet to infra-red, is crossed by numerous dark lines, called the Fraunhofer's lines. The solar radiations, while passing through the earth's atmosphere, undergo modifications in intensity due to partial scattering by molecules forming the constituents whose dimensions are smaller than the wave-lengths of radiations. Some of them are absorbed by gases and vapours even though they are present in comparatively small quantities in the atmosphere. In the visible and infra-red regions, the absorption is mainly due to oxygen, water vapour and carbon dioxide. Nitrogen absorbs but feebly. Oxygen has characteristic absorption bands in the visible as well as in the infra-red regions. Water vapour plays a very great part in the absorption of solar radiations. Though remarkably transparent in the visible region it absorbs completely a wide range of radiations in the infra-red. Carbon dioxide has its absorption band also in the infra-red, overlapping that of water vapour to a certain extent, and extending even farther towards the longer wave-length side. In the ultra-violet region the absorption is mainly due to ozone from 3000Å–2200Å. The presence of solar radiations below 2200Å has recently been detected by Edgar Meyer [1], who photographed the solar spectrum in the region 2100Å at the high altitude of Jungfraujoch.

The solar radiations which reach the earth's surface can be broadly divided into two parts. One part includes the ultra-violet, the visible and the shorter infra-red rays, which reach us directly from the sun and indirectly through reflection and diffusion, etc. by the cloud drops, air molecules and other atmospheric impurities, while the other consists only of longer infra-red rays which are emitted by the earth after it absorbs the rays which are incident directly from the sun. Of the first part only a small portion of radiations in the ultra-violet region is of special interest to the biologist and bacteriologist.

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Though the effects of solar radiations on human and animal systems were noticed by early investigators, it is only recently that a systematic investigation has been made. In 1922 Hausser and Vahle[2] measured the effect of equal amounts of radiation energy at various wave-lengths in producing erythema on human skin. They found it to be maximum at 2970Å and feeble at 3130Å. It was also supported by the subsequent observation of Hess and Weinstock[3] indicating that the upper limit of antirachitic rays was at 3130Å. The ultra-violet therapy for the cure of rickets depends on the change of the skin-ergosterol to vitamin-D. Hence for the cure of rickets the light source whose radiation best influences ergosterol photochemically should only be used. The source of radiation for this purpose should contain wave-lengths shorter than 3300Å as has been revealed from different investigati ons. The inability of the longer waves to act photochemically can be noticed from the absorption spectrum of ergosterol, the absorption for longer waves being practically zero. About the photo-chemical reaction Reerink and Wijk[4] have shown that all waves shorter than 3300Å are not equally active in the conversion of ergosterol. In fact, the region can be divided into two parts viz., 3300Å to 2820Å and waves shorter than 2800Å so far as this reaction is concerned. The region from 3300Å to 2820Å is active in producing vitamin-D, the shorter section below 2820Å, though photochemically active, produces only a smaller quantity of vitamin-D in addition to other products of no antirachitic value. Thus one finds that only a definite range of ultra-violet waves is better suited for therapeutic purposes. Regarding the comparative behaviour of artificial sources like the quartz mercury vapour lamp and the natural light of the sun in the formation of vitamin-D, Wijk, Reerink and Morikofer[5] found that in increasing the ultra-violet dose the maximum absorption coefficient of ergosterol is diminished. The maximum absorption is near about 2950Å for solar radiation, while for the mercury-vapour lamp it is confined only to the line 2967Å in its spectrum. Moreover, the sun-light is a quicker vitamin-D producer, the radiation in the region 3150Å having the maximum photochemical effect. Again, some diseases as tuberculosis seem to respond better to sun-light than the radiations from artificial sources. It is thus of great importance to ascertain the intensity distribution of the ultra-violet solar radiations. In fact such a study is being done in different parts of the world. The question of the "right of light" has also recently engaged the attention of the different nations.

A series of investigations regarding the solar radiation was taken up between the years 1911–1913 by Kron[6] in Potsdam and Dember[6] in the island of Teneriffe. By using a cadmium photo-electric cell they derived the value of the transmission coefficients of light from day to day. But it was Dorno[6] at Davos who organised systematic work on these lines extending over several years using an improved form of the photo-cell which was adopted as a standard by the later investigators of his school. In 1920 Coblentz[7] published records of the ultra-violet energy of the sun as measured with his copper constantan thermo-junction at Washington. He showed that on clear days wave-lengths shorter than 3000Å were responsible for about 2% of the solar energy that reaches the earth's surface. A more thorough investigation on the extreme ultra-violet solar radiations of wave-lengths less than 3130Å is due to Coblentz and Stair [8] in 1931. Quite recently these authors [9] have published the records of extreme ultra-violet solar intensity at Washington, Sanjuan and Flag-staff. They have given the technical details for evaluating ultra-violet solar radiations by two closely agreeing methods of balanced thermopile and photoelectric ultra-violet meter. In 1933 Laurens and Mayerson [10] reported the data taken at New Orleans on the intensity and distribution of solar radiation over a period of 56 months by the radiometer method exactly on the lines of Coblentz. The range taken was from extreme ultra-violet to far infra-red. Diurnal and seasonal variations of ultra-violet content was also measured. In India there has been, however, very little progress in this field of investigation. Excepting the casual observation of H. Suring [11] at Agra in 1924 and of Mukherjee, Boyd and Bose [12] at Calcutta in 1930, no comprehensive data on the subject are available. The present investigation was therefore taken up with a view to carry out a detailed study of the extent of the ultra-violet solar radiations and their intensity distribution at different times of the day and at different days of a month extending over one complete year.

Intensity Measurements.

In the earliest investigations the bolometer has been extensively used for the determination of the intensity of solar radiation. With the extended surface used in this instrument it does not enable one to secure the effect for any restricted zone of radiation. In fact, the records with this apparatus indicate the total energy. Further, owing to the delicate nature of the instrument, it is not suitable as a portable one.

In the early nineties Elster and Geitel [13] discovered the photoelectric effect of different substances and devised the well known photoelectric cell for obtaining a quantitative measure of the intensity of the rays in their investigation. Later on, they used the cadmium photoelectric cell in a quartz bulb filled with argon and extended the usefulness of the apparatus to shorter wave-length region and attained an accuracy of 1–2% which can be measured with a sensitive galvanometer. In fact, as has been stated previously, Kron and Dember as well as Dorno used this instrument for their investigations. The method is no doubt useful in high sensitivity work but the greatest drawback with this instrument is its selective response depending on wave-length. It further requires constant calibration against a standard to secure comparable results.

The other methods for the determination of intensity which have also been used by a large number of investigators depend upon the photo-chemical action of light. Of these, the Iodine method of Behring and Meyer [14], the Silver Citrate method of Victor Henri [15], Eder's photometric method [16], Actinometer of Bordier and Acetone Methyl Blue method of Hill [17] are worth mentioning. The last method is the simplest in operation but, besides the fact that its effect is spread over a zone of radiation, it has been found that the absolute purity of the chemicals is an essential factor in arriving at concordant results.

In the present investigation the photographic photometric method is used for the accurate measurements of intensities of line and band spectra. The method resolves itself into two operations. The first part consists in taking spectrograms of the desired radiation along with that of a standard source with same time of exposure, and the second part consists in the measurement of intensity by securing a micro-photometric record of the degree of blackening produced in the different spectral range by the two sources. The spectrograms were taken with a Hilger E_3, quartz spectrograph in which the entire spectral region was recorded on an ordinary quarter size photographic plate, along with a comparison spectrum of normal iron arc on the same plate, the time of exposure being half a second in each case. For preliminary observations the spectrograph was so disposed that the rays were normally incident on the slit. To avoid a special mounting for the spectrograph so as to have the collimation axis along the line of solar beam, it was thought desirable to have a reflecting system which would enable the beam, for different altitudes of the sun, to proceed along the line of collimation of the instrument. At first quartz right-angled prism was tried to direct the solar beam on the slit and finally a stainless steel mirror was used as a reflector for the same purpose. Ilford Empress plates were used and these were developed with a standard developer recommended by the manufacturers and the developing was conducted at 67° F., this being the temperature at which the plates yield the best contrast.

The extent of the ultra-violet changes during the course of a day, the maximum being found for about 3 hours of the noon time, was found to decline in the morning as well as in the afternoon. The limit also undergoes variation from month to month in a year reaching the maximum for about two months viz., in June and July and minimum in September.

TABLE I.

Extent of the shortest wave-length in the spectrum for clear days throughout the year.

(From August 1931 to July 1932.)

Months.		Wave-lengths in Å.		
		Morning 8 A.M.	Noon 12 A.M.	Afternoon 4 P.M.
August	14th ..	3057	2965	3200
	15th ..	3100	2037	3151
	21st ..	3009	2965	3075
	22nd ..	3100	2965	3209
	23rd ..	3151	2965	3166
September	14th ..	3057	2959	3440
	15th ..	3009	2959	3440
October	7th ..	3004	2959	2965
	10th ..	3000	2959	2987
	11th ..	2994	2959	2994
November	16th ..	3057	2965	3100
	25th ..	3075	2965	3125
	27th ..	3100	2965	3209
	28th ..	3067	2965	3151
December	3rd ..	3083	2965	3026
	4th ..	3100	2965	3016
	5th ..	3057	2965	3026
	7th ..	3083	2959	3009
January	4th ..	3100	2965	3009
	5th ..	3248	2965	3009
	6th ..	3100	2965	3009
	8th ..	3100	2959	3009
February	1st ..	3100	2965	3009
	2nd ..	3100	2965	3009
	10th ..	3083	2959	2994
	11th ..	3057	2959	2987
	17th ..	3057	2959	2973
	18th ..	3057	2959	2973
March	3rd ..	3100	2947	3026
	10th ..	3016	2947	3026
	11th ..	3026	2947	3026
	23rd ..	3026	2947	3009
April	7th ..	3016	2947	3009
	8th ..	3016	2947	3009
	9th ..	3009	2947	3026
	21st ..	2994	2947	3009
	22nd ..	2994	2947	3009
May	11th ..	2994	2947	3008
	12th ..	2994	2947	3009
	19th ..	2973	2947	3016
	20th ..	2973	2947	3016
	21st ..	2994	2958	3026
June	15th ..	3009	2947	2994
	17th ..	3009	2947	2994
	20th ..	3009	2959	3016
	30th ..	2980	2953	2994
July	5th ..	2994	2947	*
	9th ..	2994	2947	*
	18th ..	3009	2947	*

* (Records of the afternoon are untrustworthy as the evening sky was very dull and dust-laden).

Table I shows the extent of the shortest wave-length for the clear days of each month from August, 1931 to July, 1932. There is a further point to note viz., that the extension remains sensibly constant during the period from August to December. From January till the middle of May one finds that the limit proceeds towards the shorter wave-length side. After the month of May the limit of the spectrum again proceeds towards the longer wave-length. The mean values of the limits in each month are shown in the following table.

TABLE II.

Mean values of the limits of extension in the short wave-length region of the spectrum.

Months.	Wave-lengths in Å.		
	Morning 8 A.M.	Noon 12 A.M.	Afternoon 4 P.M.
August	3083	2979	3160
September	3083	2959	3440
October	3001	2959	2982
November	3074	2965	3146
December	3080	2963	3019
January	3137	2963	3009
February	3075	2962	2990
March	3035	2947	3019
April	3005	2947	3012
May	2985	2953	3015
June	3001	2951	2999
July	2999	2947	....

The theoretical relation governing the intensity of spectral line and the density of blackening has been fully treated by Ornstein[18] and his collaborators.

If S = density of blackening,

I = Intensity of any spectral line,

and I_0 = constant intensity of the same wave-length for the plate used the relation stands as

$$S = \gamma \log \frac{I}{I_0}, \quad .. \quad .. \quad .. \quad .. \quad (1)$$

where γ is the characteristic constant of the photographic plate in question depending upon its sensitivity in the particular region.

Thus if one could secure a quantitative relationship between the density of blackening due to radiation of the desired wave-length in the plate and the density of blackening for the standard source for the same wave-length one could get a measure of the intensity. To get this measure of blackening one has to determine the ratio of the transmission energy of any constant source of light through the clear portion of the photographic plate and that through the desired line in the spectrum.

For if D_0 is the measure of the transmission through the clear plate and $D =$ that through the blackened line, the law of absorption shows that the density of blackening produced by the line in question can be stated as

$$S = \log \frac{D_0}{D}, \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad (2)$$

where S is the measure of the density of blackening.

Thus, instead of directly comparing the intensity from the blackening, if one takes into consideration the law of absorption, one finds a quantitative expression for the density of blackening for each individual line of the spectral region. Further, as shown in the expression (1) the intensity I bears a logarithmic relation to any other intensities producing the different density of blackening and involving at the same time a coefficient γ which is the characteristic of the plate.

It resolves thus, in determining accurately the spectral line intensities, to find values of the transmission coefficient of a constant source of light through a clear photographic plate and the coefficient through different points of the record of the spectrum, the coefficients being measured from the datum line corresponding to no deflection position when no energy falls on the thermocouple. The apparatus devised to secure this coefficient is a microphotometer. In our investigation, we have used a standard microphotometer designed by Moll. With the help of this microphotometer one can notice that a point to point record of the transmission factor of a constant source of light through any photographic plate can be secured. Thus if the maximum deflection—namely, that produced by a transmission through a clear photographic plate be D_0 and the deflection through any desired point of the photographic plate be D, the ratio $\frac{D_0}{D}$ is measured from a datum line where there is no deflection and from the law of absorption previously mentioned (Equation 2) one gets the values

$$S = \log \frac{D_0}{D}.$$

It now remains to secure the standardising factor of the plate itself. To secure this one would require a standard source of light which has a spectrum in the desired region. Since our object is to measure the ultra-violet intensity we selected the ultra-violet radiation free from any discontinuity. Such a source has now been available as the hydrogen discharge tube devised by Lau. On one side of the tube there are two electrodes and it requires an alternating potential of about 3000 volts to excite the discharge in the tube. Four small side tubes containing aluminium foils serve to check occlusion of the hydrogen inside the glass and this arrangement has been found very successful in producing a continuous source of radiation up to the extreme ultra-violet free from any line source. In previous works, for standard of calibration a quartz mercury vapour lamp has often been used. Since, as is well known, such a mercury vapour lamp emits only discrete lines of varying intensities in the ultra-violet region, it is not suitable as a standard of comparison in the ultra-violet region. The use of an incandescent lamp is primarily beset with the difficulty, namely that ordinarily glass bulbs are used as an enclosure and furthermore that the intensity of such a lamp even if provided with a quartz envelope diminishes with time, due to the sputtering action on the envelope from the heated filament.

The radiation from such a hydrogen discharge tube can be photometrically compared with the well known standards of illumination as the pentane lamp (British standard) and amyl acetate lamp (German standard) for the visible region. In our investigation, however, we have not secured this comparison because we find that the radiations from this discharge tube can be used also as a standard in the ultra-violet region and it does not suffer from the uncertainties previously explained and, further, that in the several plates that we have so far examined, its constancy has been found to be invariable,

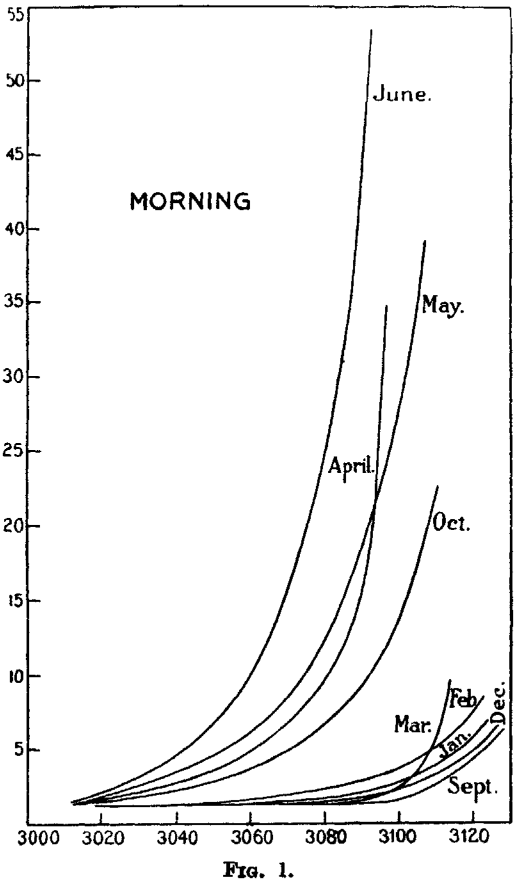

FIG. 1.

provided the applied voltage is constant and the tube allowed to run for half an hour before taking the exposure.

It now remains to explain the method of securing the plate characteristics γ and I_0. For this purpose it is necessary to get a number of spectra with varying intensity of the standard source in our plate with the same spectrograph that we used in our investigation. To produce such spectra we have adopted the device suggested by Ornstein. It consists of a number of slits of varying width to be fitted on the slit end of the spectrograph. In our experiment we used five slits whose openings have been measured carefully with a micrometer microscope. The intensities of the different spectra formed by the slits would be naturally proportional to their widths. From this

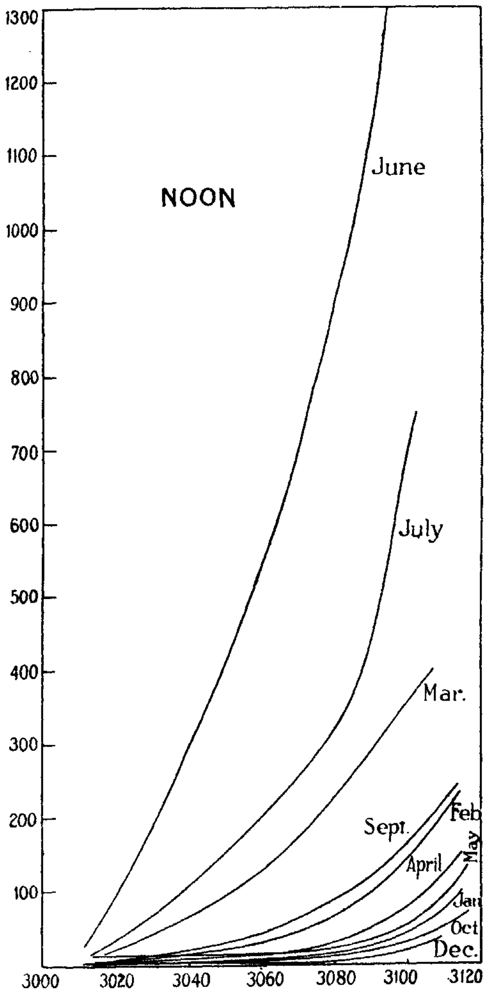

FIG. 2.

photographic record another set of microphotometer traces were next obtained and with the application of the principles explained above we get a record of the transmission coefficients for different slit widths. The table below shows the blackenings corresponding to different slit widths for λ 3050.

TABLE III.

Slit width.	Blackening.
·1 mm	·060
·25 „	·093
·40 „	·152
·60 „	·187

A graph was plotted to evaluate the contrast factor γ and the sensitivity I_0 of the plate for λ 3050 by measuring the slope and the point of intersection of the straight portion of the curve in question with the horizontal axis. The next procedure is to secure the values of intensities of the different spectral regions from the constant thus derived, it being assumed that γ and I_0 were constant for the short region of wave-length investigated. Table IV

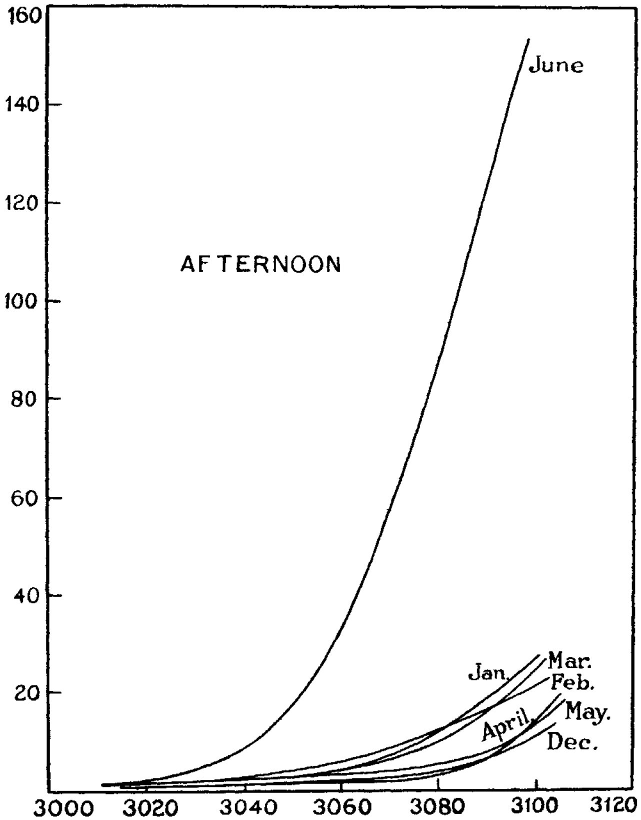

FIG. 3.

shows the intensities for different wave-lengths throughout the year, the unit of intensity being that corresponding to the radiation produced by the hydrogen tube placed at a distance of one metre from our spectrograph having the slit width of one millimetre. In fact, if the radiation from the standard hydrogen discharge tube is constant, and if any recording source for spectral observation is placed at a metre distance from this with an aperture as an opening of one millimetre, the results would be comparable, the exposures being of the same duration in the two cases.

The results of table IV have been graphically plotted in Figs. 1, 2, 3. These plates have been drawn in different scales. From this it appears that the ultra-violet intensity is highest in the month of June and decreases rapidly towards the months of May and July. It is also interesting to note that the curves for the months of March, April, May, June and July are of a different character from those of the other months. It appears that the rate of rise of intensity in this region happens to be more rapid towards the longer wave-length side tending to show that in these months the long wave-lengths of luminous rays and heat rays are also very intense.

If we confine our interest to the zone which extends from 3100Å to 3000Å it would be proper to ascertain the values of the intensity for a mean radiation 3050Å. These values have been obtained from table IV; table V shows the values of intensities for each month of the year 1931-32 and at different times of the day.

TABLE IV.

Intensities of the Ultra-Violet Solar Radiation at Calcutta from September, 1931 to July, 1932.

(Morning, Noon and Afternoon.)

Months.	Morning.		Noon.		Afternoon.	
	Wave-length in Å.	Intensity.	Wave-length in Å.	Intensity.	Wave-length in Å.	Intensity.
September ..	3103	2·69	3101	147·9	3092	8·70
	3096	2·29	3094	128·8	3075	5·49
	3085	2·08	3076	77·6	3072	5·75
	3079	1·51	3070	56·2	3042	3·38
	3071	1·48	3055	51·3	..	..
	3058	1·38	3041	5·25	..	..
	3051	1·35	3028	4·26	..	..
	3046	1·35	3011	2·45	..	..
	3026	1·35	..	..	..	..

TABLE IV—(*contd.*)

Months.	Morning.		Noon.		Afternoon.	
	Wave-length in Å.	Intensity.	Wave-length in Å.	Intensity.	Wave-length in Å.	Intensity.
October	3105	17·8	3106	38·0	..	..
	3092	9·12	3092	17·8	..	..
	3083	7·24	3085	17·8	..	..
	3061	4·26	3075	13·8	..	..
	3055	3·38	3061	10·9	..	..
	3039	2·14	3052	6·92	..	..
	3022	1·38	3042	8·13	..	..
	3013	1·38	3037	6·45	..	..
	..	..	3035	5·75	..	..
	..	..	3016	2·29	..	..
December ..	3100	1·44	3091	7·08	3099	6·91
	3090	1·38	3081	7·08	3091	6·02
	3078	1·38	3072	7·76	3082	6·45
	3072	1·35	3057	4·89	3067	3·55
	3056	1·28	3052	3·05	3058	2·51
	3044	1·28	3040	3·71	3047	2·34
	3025	1·28	3028	2·75	3039	1·90
	3016	1·28	..	..	3026	1·51
	..	..	..	..	3018	1·38
January	3099	1·78	3102	38·0	3100	16·6
	3092	1·78	3093	38·0	3092	16·6
	3087	1·78	3081	56·2	3081	19·5
	3082	1·62	3073	56·2	3073	19·5
	3078	1·62	3063	29·5	3065	9·12
	3072	1·58	3053	15·5	3059	4·67
	3065	1·51	3040	17·8	3046	5·25
	3058	1·48	3033	14·4	3040	3·71
	3052	1·51	3028	11·7	3036	3·16
	3046	1·58	3018	13·8	3028	3·38
	3036	1·58	3011	7·60	3021	2·04
	3032	1·58	3009	2·75	3016	1·38
	3021	1·58	..	..	..	..
February	3105	3·80	3106	169·8	3107	16·9
	3098	3·02	3101	56·2	3098	16·9
	3088	3·02	3090	128·8	3089	21·4
	3075	2·04	3084	169·8	3076	10·9
	3066	1·78	3075	45·7	3067	7·24
	3055	1·62	3066	29·5	3056	7·24
	3050	1·58	3056	31·6	3047	5·01
	3046	1·51	3048	26·9	3032	1·90
	3039	1·48	3045	38·0	3015	1·58
	3034	1·28	3037	26·9	..	..
	3026	1·38	3032	15·5	..	..
	3018	1·38	3028	6·02	..	..
	..	..	3014	6·02	..	..
March	3106	4·46	3104	269·1	3102	21·4
	3105	3·55	3097	269·1	3095	17·8
	3103	3·38	3087	316·2	3084	17·8
	3100	1·86	3071	169·8	3070	6·91
	3099	1·51	3064	100·0	3064	3·80
	3096	1·38	3053	128·8	3052	3·38

TABLE IV—(*contd.*)

Months.	Morning.		Noon.		Afternoon.	
	Wave-length in Å.	Intensity.	Wave-length in Å.	Intensity.	Wave-length in Å.	Intensity.
March—(*contd.*) ..	..	..	3047	100·0	3044	2·29
	..	..	3044	87·1	3031	1·62
	..	..	3036	100·0	3027	1·44
	..	..	..	..	3020	1·62
	..	..	..	..	3015	1·48
Aprîl	3098	24·5	3095	51·3	3005	19·5
	3090	19·5	3087	51·3	3097	6·90
	3080	22·9	3077	63·1	3088	5·75
	3063	5·01	3063	38·0	3079	5·75
	3058	3·71	3054	26·9	3072	5·50
	3039	2·45	3043	31·6	3064	3·16
	3019	1·51	3034	21·4	3056	2·45
	..	..	3016	6·45	3045	2·29
	..	..	..	..	3034	1·86
	..	..	..	..	3016	1·38
May	3101	31·6	3107	70·8	3105	16·9
	3087	13·8	3097	26·9	3096	6·45
	3080	11·7	3089	29·5	3088	5·75
	3072	13·8	3080	34·6	3079	6·02
	3058	6·91	3065	22·9	3073	6·02
	3052	4·46	3062	29·5	3066	3·38
	3044	4·26	3057	15·5	3058	2·34
	3039	3·16	3047	14·4	3049	2·34
	3035	2·95	3040	14·4	3040	1·78
	3029	2·75	3036	13·8	3032	1·78
	3020	1·69	2029	14·4	3026	1·57
	3014	1·51	3025	9·12	3021	1·35
	..	..	3019	4·26	3014	1·38
	..	..	3013	9·12	3011	1·38
June	3101	50·1	3101	1096·5	3102	138·0
	3093	40·7	3093	851·1	3094	112·2
	3082	45·7	3084	1230·3	3076	128·8
	3068	15·5	3068	691·8	3070	45·7
	3062	8·71	3061	457·1	3962	21·4
	3051	7·58	3050	562·3	3051	19·5
	3044	4·46	3042	316·2	3042	9·55
	3025	1·69	3034	380·2	3030	4.26
	3015	1·58	3028	199·5	3024	2·08
	..	..	3024	51·3	3013	1·78
	..	..	3012	77·6	..	..
July	..	..	3106	691·8	..	..
	..	..	3092	316·2	..	..
	..	..	3084	316·2	..	..
	..	..	3075	562·3	..	..
	..	..	3063	229·0	..	..
	..	..	3055	128·8	..	..
	..	..	3046	147·9	..	..
	..	..	3037	100·0	..	..
	..	..	3030	112·2	..	..
	..	..	3021	17·8	..	..
	..	..	3011	24·5	..	..

TABLE V.

Time	Jan.	Feb.	March	April	May	June	July	Sept.	Oct.	Dec.
Morning	1·51	1·58	..	3·2	4·46	7·58	..	1·35	2·98	1·28
Noon	16·00	88·00	114·50	28·00	14·70	562·30	139·50	35·00	6·92	3·55
After-noon	5·00	5·74	3·18	2·36	2·34	19·5	..	4·25	..	2·39

The curves corresponding to table V are shown in Fig. 4. There is also another special feature of the intensity relation shown in this figure namely, that the ultra-violet content in the afternoon of April and May is less than that in the morning of the same months. In all the other months the rising sun has less ultra-violet content than the setting sun. As a probable explanation for this phenomenon one has to remember that these are the driest months of the year and the wind movements, specially those due to the occasional Nor'westers, may carry the finer dust particles from the surface region to heights above the ground and may act as scattering centres to the incident radiation. Now, considering the winter months both in the morning and noon, the intensity of the mean spectral region, namely at 3050Å, is found to rise as one proceeds from January to March. The curve for the afternoon, however, shows a diminution in intensity. In a crowded commercial city like Calcutta with its number of small house fires one can reasonably understand that the atmosphere would be polluted by the smoke arising from these causes, specially in the evening time, and due to the falling temperature this tends to set up condensation nuclei of the water vapour in the lower region of the atmosphere surrounding the city. Another point that may be noticed from the curves is that, excepting the months of March, June, July and August, most of the months are rather very poor in ultra-violet radiation at all hours of the day.

In connection with the above statement regarding the variation of intensity it may here be mentioned that, though the direct ultra-violet intensity is very feeble in some months, the scattered sky radiation, which is equally beneficial, may be a fair proportion of the total radiation.

The table shows a peculiar fall in intensity near about the wave-length 3100Å. It is the much familiar OH band of the solar spectrum due to the presence of dissociated water vapour in the atmosphere.

It may be mentioned here that a thorough investigation into the possibility of best utilising the solar rays for different purposes requires more elaborate and extensive work on the subject. In this connection it is necessary to point out that the intensity of ultra-violet radiation alone will not serve as a criterion for

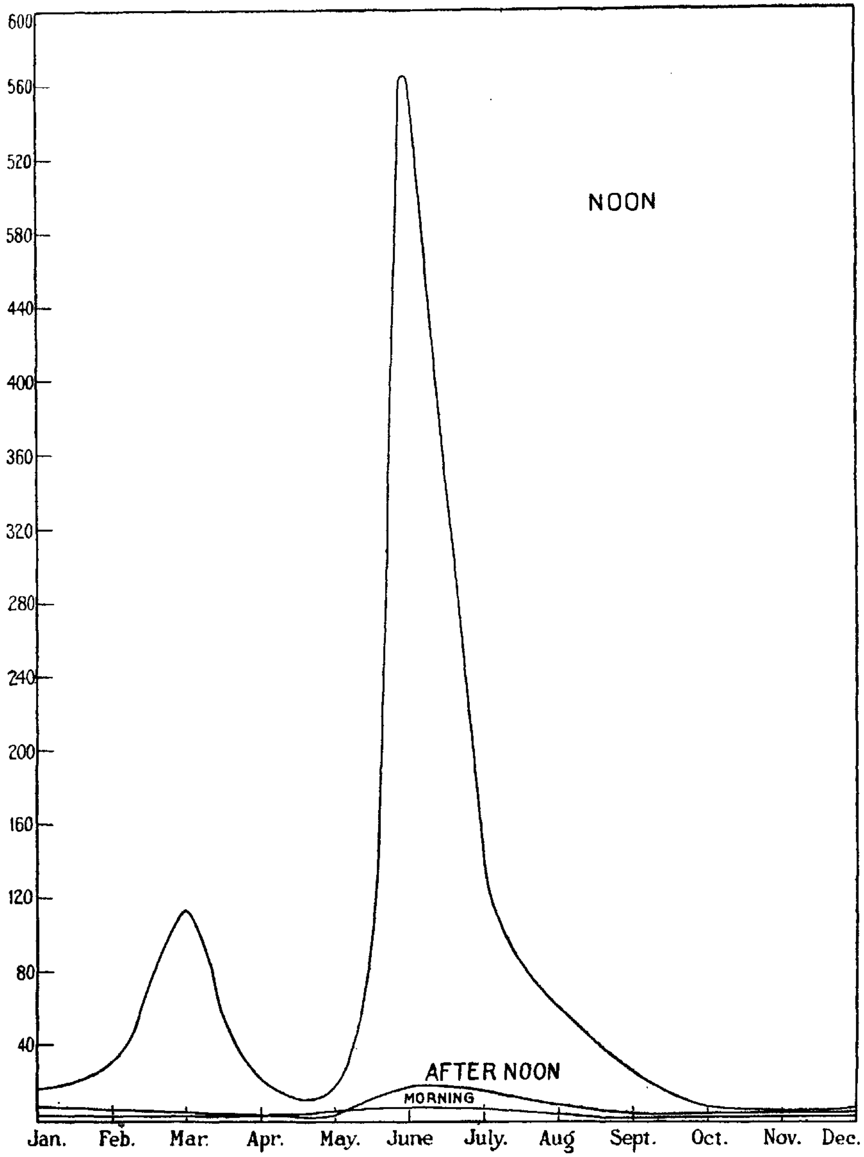

Fig. 4.

utilising the beneficial effect of solar radiation. For animal and human systems one would consider along with it the intensity of radiation in the thermal region. In fact, to utilise it to the fullest extent it would be proper to avoid as much as possible the effect of the heat rays since they would tend to react harmfully on the system due to their temperature effect. So far as the present literature on the subject shows, we have not sufficient data about this factor. It will be worth while to ascertain the relative proportion of the intensity of the heat rays and the ultra-violet rays and then to select the particular period of the year and the particular time of the day to secure optimum beneficial effects of ultra-violet radiation. With the new infra-red plate now commercially available extending into the far heat region it would be possible to apply the method above stated for this class of investigation. Further, as a check for the total radiation in the heat region one can use the photo-electric alkali metal cells (viz., Cs and Rb) which show a maximum receptive property in this zone.

The effect of the quantity of dust and smoke in the atmosphere at different times of the day in different months upon the ultra-violet intensity may also be examined. The proportion of scattered ultra-violet radiation to direct radiation may be determined provided day to day measurement of the diameter of the scattering particles is made for a period of one year. It may not be out of place to point out that exhaustive work must be done in different centres—outside as well as inside Calcutta—in order to arrive at a definite conclusion regarding the suitability of a site for ultra-violet treatment and the effect of climate, temperature, pressure and weather conditions on the transmission of the erythemal zone.

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Summary.

The paper gives a critical survey of the different methods employed by the previous workers for the determination of the intensity of solar radiation. The photographic photometry method, which has not hitherto been used in this field of investigation, has been adopted by the present author for a similar purpose in view.

The variation in the limit of the shortest wave-length radiations in the sun-light at Calcutta during the period 1931-32 has been ascertained from spectrographic records. The distribution of intensity of the radiations in the region 3100Å—3000Å has been determined with the above mentioned method. It is found that the intensity is maximum in June and minimum in December.

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