CONFIRMATORY EXPERIMENTS ON THE VALUE OF THE SOLAR CONSTANT OF RADIATION

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Presented to the Academy, April 27, 1915

We have made hitherto nearly 1000 determinations of the intensity of solar radiation outside the atmosphere at mean solar distance, termed the solar constant of radiation. The mean value found is 1.93 calories per square centimeter per minute. Langley's spectro-bolometric method was employed. This consists in determining the distribution of the energy in the solar spectrum at different solar zenith distances, and thereby computing coefficients of atmospheric transmission suitable to determine the energy curve outside the atmosphere. The bolometric measurements are reduced in terms of standard 15° calories per square centimeter per minute by the aid of comparisons made each day of observation with standardized pyrheliometers. Observations have been made at Washington (sea level); Bassour, Algeria (1160 meters); Mount Wilson, California (1730 meters); and Mount Whitney, California (4420) meters. They have continued during all the years 1903 to 1914. Great changes from day to day and from place to place in temperature, in barometric pressure, in humidity, in haziness, while of course greatly affecting measurements of intensity at the stations, and of atmospheric transparency computed, nevertheless have not produced differences of the solar constant values. This seems to us to be strong evidence of the soundness of the method.

In the second place it has been shown by Fowle that the atmospheric transmission coefficients obtained at Mount Wilson fit well with Lord Rayleigh's theory of atmospheric scattering, except for those regions of spectrum where numerous atmospheric lines and bands of true absorp-
tion are known to occur. Fowle has computed from the transmission coefficients that the number of molecules per cubic centimeter of air at standard temperature and pressure is \((2.70 \pm 0.02) \times 10^{19}\). This value is very close to Millikan’s determination by absolutely independent observations and methods, namely \((2.705 \pm 0.005) \times 10^{19}\).

In the third place simultaneous solar-constant observations at Mount Wilson and Bassour, separated by one-third the earth’s circumference, unite in showing a substantial irregular variability of the sun from day to day. This solar variability has been of late independently confirmed by us by examination of the distribution of brightness along the diameter of the sun’s disk. The latter observations show variations of distribution from day to day, and these accompany pretty closely the variations of the total solar radiation. It seems to us that, as the fact of solar variability is thus independently confirmed as a real phenomenon, it speaks favorably for the substantial accuracy of our solar constant measurements that it was through them that the irregular variations of from 1 to 5 or, very rarely, 10% were first discovered.

Notwithstanding these evidences of the soundness of our solar constant work, various attacks upon it have been made, tending to show that the solar constant is much higher than 1.93 calories, perhaps even 3.5 to 4.0 calories. A principal argument is that the atmospheric transparency continually diminishes as the sun rises within 75° zenith distances, so that our values of atmospheric transmission are much too great, and have no relation to the transmission of an atmosphere of constant transparency. Secondly it is said that measurements of solar radiation exceeding 1.93 calories have been made on mountain tops, and from free balloons. Various other objections are raised, which we discuss in our paper now being published by the Smithsonian Institution.

On two days, September 20 and 21, 1914, we continued solar constant observations at Mount Wilson from the instant of sunrise until about 10 o’clock. We have reduced the work by the aid of Bemporad’s air-mass formulae and tables. As these postulated uniform optical quality of the atmosphere from bottom to top, it was necessary to apply certain corrections to them varying with the wave-length, depending upon the extinction by water vapor residing in the lowest atmospheric strata. We were enabled to determine these corrections by Fowle’s studies of the effects of water vapor. We find on both days that the atmospheric transparency remained sensibly unaltered from sunrise to 10 o’clock. Closely identical values of the solar constant are obtained, whatever the range of air masses used to determine the atmospheric transmission. We made three independent estimates for each
day, for air-mass ranges 1.3 to 4; 4 to 12; and 1.3 to 20 air-masses, respectively. All six solar constant values thus found fall between 1.90 and 1.95 calories. The smallest air masses, as it happens, yield slightly the highest values. We conclude that our previous results have not been made too small by neglecting to observe during the time when the sun is within 15° of the horizon.

On July 11, 1914, in cooperation with the United States Weather Bureau, a recording pyrheliometer attached to sounding balloons was sent up to the altitude of about 24 km., where the barometric pressure was 3 cm. of mercury, which is only one twenty-fifth of that which prevails at sea level.

Good records of solar radiation were obtained over a period of more than an hour, and including the period when the instrument reached highest elevation. The mean value of the best three records made at highest altitudes, as reduced to mean solar distance, comes out 1.84 calories per cm.² per minute. We believe about 2% should be added to represent radiation scattered and absorbed in the atmosphere above the level reached, making for the probable value of the solar constant, from this day's work, 1.88 calories. This value falls decidedly within the range of solar constant values we have observed. We state in connection with it the following results which are the highest reliable direct observations of solar radiation at the various altitudes, as reduced to mean solar distance and vertical sun:

<table>
<thead>
<tr>
<th>Station</th>
<th>Washington</th>
<th>Mount Wilson</th>
<th>Mount Whitney</th>
<th>Manned Balloon</th>
<th>Free Balloon</th>
</tr>
</thead>
<tbody>
<tr>
<td>Altitude</td>
<td>127 m.</td>
<td>1730 m.</td>
<td>4420 m.</td>
<td>7500 m.</td>
<td>24000 m.</td>
</tr>
<tr>
<td>Barometer</td>
<td>75 cm.</td>
<td>62 cm.</td>
<td>45 cm.</td>
<td>30 cm.</td>
<td>3 cm.</td>
</tr>
<tr>
<td>Radiation</td>
<td>1.58</td>
<td>1.64</td>
<td>1.72</td>
<td>1.755</td>
<td>1.84 cal.</td>
</tr>
<tr>
<td>Observer</td>
<td>Kimball</td>
<td>Abbot</td>
<td>Abbot</td>
<td>A. Peppier</td>
<td>(Smithsonian)</td>
</tr>
</tbody>
</table>

VARIATION OF FLOWER SIZE IN NICOTIANA

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Presented to the Academy, April 28, 1915

During the past five years considerable attention has been given to the study of the inheritance of flower-size in Nicotiana at the University of California Botanical Gardens. In the course of these investigations it has been found that flower size varies markedly under different conditions attending development. This report is concerned with an analysis of some of these conditions, and the bearing of such variations on the study of flower-size inheritance in Nicotiana.