Fig. 8.17

8.26 Solar Constant

The sun is the source of heat radiations and it emits heat radiations in all directions. The earth receives only a fraction of the energy emitted by the sun. The atmosphere also absorbs a part of the heat radiations and air, clouds, dust particles etc. in the atmosphere scatter the heat and light radiations falling on them. From the quantity of heat radiations received by the earth, it is possible to estimate the temperature of the sun. Therefore, to determine the value of a constant, called *solar constant*, certain ideal conditions are taken into consideration.

Solar Constant. *It is the amount of heat energy (radiation) absorbed per minute by the sq cm of a perfectly black body surface placed at a mean distance of the earth from the sun, in the absence of the atmosphere, the surface being held perpendicular to the sun's rays.*

The instruments used to measure the solar constant are called pyrheliometers. The heat energy absorbed by a known area in a fixed time is found with the help of the pyrheliometer. To eliminate the effects of absorption by the atmosphere, the value of the solar constant is found at various altitudes of the sun on the same day under similar sky conditions. If S is the observed solar constant, S_0 the true solar constant and Z the altitude (angular elevation) of the sun, then

$$S = S_0 a^{\sec Z}$$

or

$$\log S = \log S_0 + \sec Z \log a \quad \text{... (8.18)}$$

Here a is a constant.

A graph is plotted between $\log S$ along the y-axis and $\sec Z$ along the x-axis. The graph is a straight line. Produce the graph to meet the y-axis. The intercept on the y-axis gives $\log S_0$. From the value of $\log S_0$, the value of S_0, the solar constant can be calculated. The value obtained varies between 1.90 and 2.60 calories per sq cm per minute.

8.27 Temperature of the Sun

The sun consists of a central hot portion surrounded by the photosphere. The central portion has temperature of the order of 10^7 K. The photosphere has a temperature of about 6000 K. This temperature is also called the effective temperature of the sun. Considering the sun as a perfect black body radiator, the temperature of the sun can be calculated.

Let the mean distance of the sun from the earth be R and S the solar constant. Then, the total amount of heat energy received by the sphere of radius R in one minute = $4\pi R^2 S$.

If r is the radius of the sun, then the amount of heat energy radiated by 1 sq cm surface of the sun in one minute

$$E = \frac{4\pi R^2 S}{4\pi r^2} = \left(\frac{R}{r}\right)^2 \times S$$

Taking

$$R = 148.48 \times 10^7 \text{ km}$$

$$r = 6.928 \times 10^5 \text{ km}$$

The mean value of

$$S = 1.94 \text{ cals per cm}^2 \text{ per minute.}$$

$$E = \left(\frac{148.48 \times 10^7}{6.928 \times 10^5}\right)^2 \times \frac{1.94}{60} \text{ cals per second} \quad ...(i)$$

Also

$$E = \sigma T^4$$

But

$$\sigma = 5.75 \times 10^{-5} \text{ ergs per cm}^2 \text{ per second}$$

$$= \frac{5.75 \times 10^{-5}}{4.2 \times 10^7} \text{ ergs per cm}^2 \text{ per second}$$

$$E = \frac{5.75 \times 10^{-5}}{4.2 \times 10^7} . T^4 \quad ...(ii)$$

Equating (*i*) and (*ii*)

$$\left(\frac{5.75 \times 10^{-5}}{4.2 \times 10^7}\right) T^4 = \left(\frac{148.48 \times 10^7}{6.928 \times 10^5}\right)^2 \times \frac{1.94}{60} \quad ...(iii)$$

$\therefore$

$$T = 5730 \text{ K}$$

This temperature gives the effective temperature of the sun acting as a black body radiator. The actual temperature of the sun is higher than this value. The temperature of the sun is usually taken as 6000 K.

Temperature of the sun can also be calculated from Wien's displacement law,

$$\lambda_{max} T = 0.2892 \quad ... (8.19)$$

The wavelength of the radiations for which the energy is maximum in the spectrum is 4900 × 10^{-8} cm.

Substituting the value of λm, the value of T comes out to be 5902 K. This value is in agreement with the accepted value. Hence, the effective temperature of the sun (photosphere) is about 6000 K.

Let us calcul...

EC-02/121

Subject : PHYSICS

Topic : Solar Constant & temperature of the sun.

Class : TDC-I & Paper-II

Date : 08-04-2021

By : Dr. U.K. Singh

Ref. : Dr. Brij Lal Book