LETTER TO THE EDITOR

Further thoughts on the solar constant

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Further thoughts on the solar constant

Frank Thompson

Department of Chemistry, EPR Centre, University of Manchester, Oxford Road, Manchester, M13 9PL, United Kingdom

E-mail: F.Thompson@manchester.ac.uk

Abstract

I read with interest the recent paper (Brizova and Slegr 2017 *Phys. Educ.* **52** 013008) regarding an experiment to measure the solar constant using a bolometer. The authors admitted that their measurements gave a value much lower than expected.

A re-plot of the data points was undertaken and the graph, figure 1, is given below.

The graph shows rising temperature values versus time with the plate reaching a final temperature of about 35 °C. The points fall on a smooth curve which has a logarithmic shape and, in theory, an infinite time is required for the plate to reach its final value.

A theoretical analysis is now given for a solar heated plate.

Assume we have plate of unit area

Let solar constant be I_{SC} W.

Power loss from cooling is $G(T - T_{amb})$ Watts where T_{amb} is the temperature of the surroundings and T is an elevated temperature. The rate of heating of the plate will be equal to the solar power input minus the rate of loss of heat.

If plate has mass m and the specific heat of the material is c then:

$$mc^{dT}/_{dt} = I_{SC} - G(T - T_{amb}).$$

Substituting a single parameter for $(T - T_{amb})$ allows integration giving:

$$e^{-t/(mc/G)} = \frac{I_{SC} - G(T - T_{amb})}{I_{SC}}.$$

Rearranging gives

$$T = T_{amb} + {}^{I_{SC}}/_{G}\,(1 - e^{-(G/mc)t}).$$

We see that the final temperature $T_{max} = T_{amb} + I_{SC}/G$.

And the initial slope is $I_{SC}/(mc)$.

Thus, the author's formula [1] only applies to the INITIAL slope of the graph and not the straight-line drawn as a 'best-fit' to all the points.

In figure 1 an estimation of the initial slope was found to be 0.065 ± 0.005 K s^{-1}, which is more than double the slope given in [1].

The value of I_{SC} is then found to be 1080 ± 50 W m^{-2}, which is a more acceptable value.

A value of G may also be estimated. Since $T_{max} - T_{amb}$ is almost 10 °C then the value of G is 108 ± 5 W m^{-2} K^{-1}.

As the authors point out, the experiment is interesting in that it lifts physics into an ASTROphysical regime.

May I add that the experiment requires little time to set up and a thermocouple sensor may be used if an IR thermometer is not available. A note of caution must be given; there are only a few data points available in figure 1 for estimating

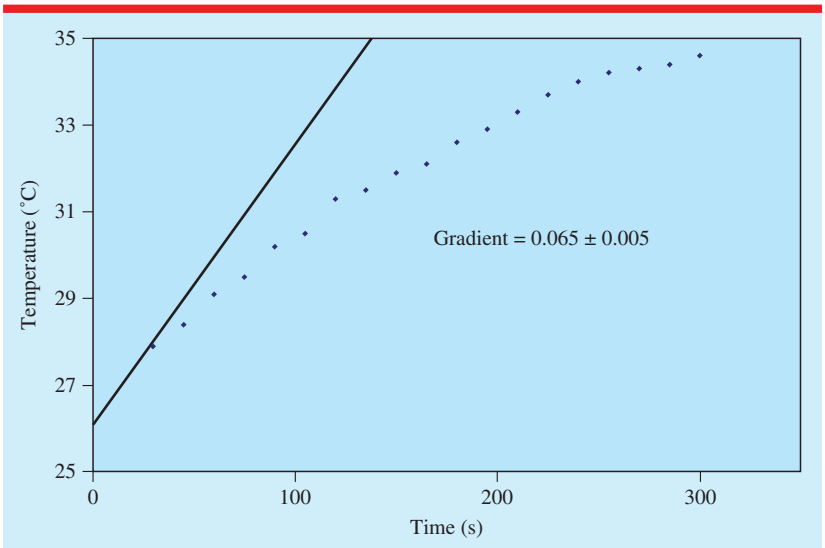

Figure 1. Graph showing the heating of a plate in a bolometer sensor.

the slope. Therefore it is usual practice to cool the bolometer below ambient temperature before placing it into the sun's rays [2].

Bolometers, of course, have much wider scope then measuring only the solar constant. They are used for detecting any visible or infra red radiation. Indeed, bolometers are sometimes used to detect microwave radiation when sensitive bridge arrangements are employed.

In summary, the authors must be complemented for setting up their apparatus outdoors to assess the amount of energy coming from the sun.

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Reference

[1] Brizova L and Slegr J 2017 Estimation of the solar constant with a simple bolometer *Phys. Educ.* **52** 013008
[2] www.start-simply.co.uk/page1-2/ (file sun8)