Measuring Power and Temperature of Sun

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Contents

1 Aim

The aim is to measure something that would be virtually impossible to measure directly, which is measuring the power and temperature of the sun.

2 Apparatus

See lab sheet.

3 Procedure

See lab sheet.

4 Diagram

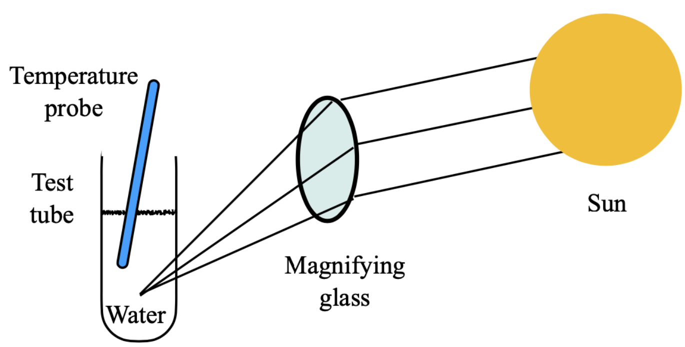

Figure 1: Theory Diagram

5 Data Collection

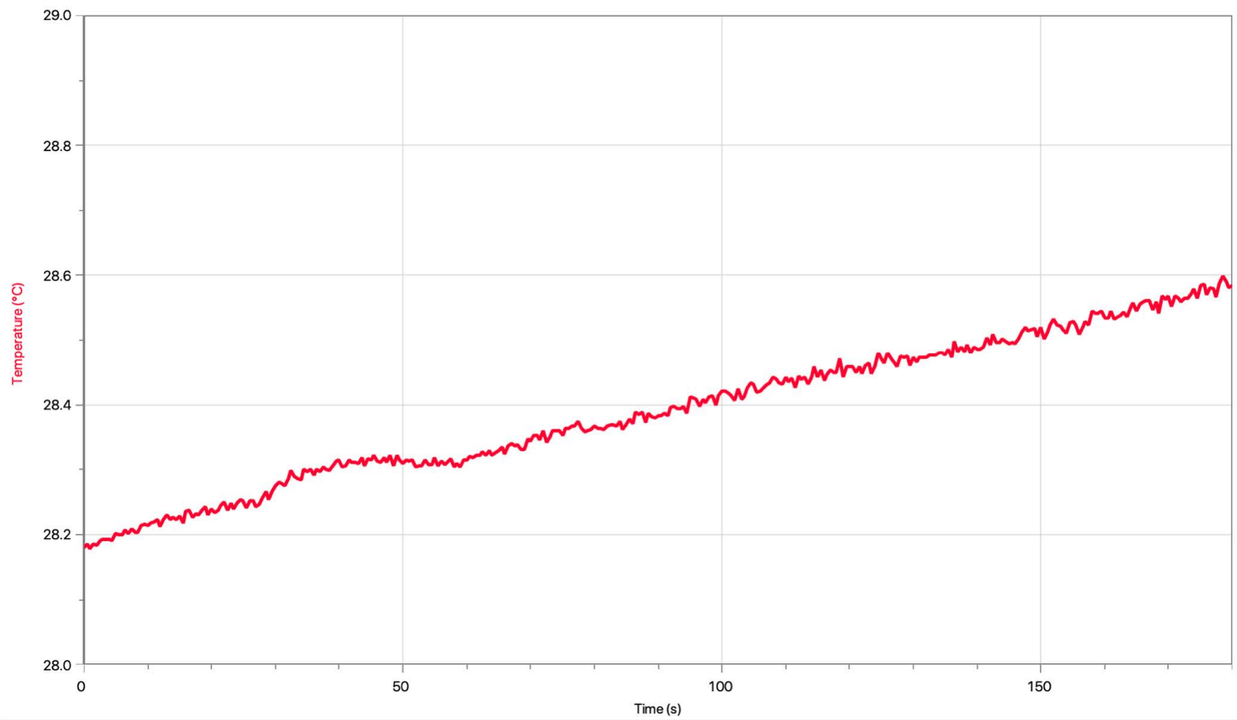

Figure 2: Data Collected

*: the conditions of current data is listed as following

Mass of water in test tube = 15g

Diameter of magnifying glass = 3.55cm

6 Data Analysis

6.1 P – Energy towards Water

By using

$$P = \frac{\triangle Q}{\triangle t} = \frac{mc\triangle T}{\triangle t}$$

where

Mass of Water: $m = 15\text{g}$

Specific Heat Capacity of Water: $c = 4.186\text{J}\,\text{g}^{-1}\,{}^{\circ}\text{C}^{-1}$

Change of Temperature: $\triangle T = 28.6 - 28.2 = 0.4^{\circ}\text{C}$

Time span: $\triangle t = 180\text{sec}$

We can then calculate the P by using

$$
\begin{aligned}
P &= \frac{mc\triangle T}{\triangle t} \\
&= \frac{15\mathrm{g}\cdot 4.186\mathrm{J\,g^{-1}\,{}^{\circ}C^{-1}}\cdot 0.4^{\circ}\mathrm{C}}{180\mathrm{sec}} \\
&= 0.140\mathrm{W}
\end{aligned}
$$

6.2 $I_{\text{at Earth}}$ – Intensity of Sun Energy at Earth

By using

$$I_{\text{at Earth}} = \frac{P_{\text{magnifying glass}}}{\pi\left(r_{\text{magnifying glass}}\right)^2}$$

where

Power of Magnifying Glass: $P_{\text{magnifying glass}} = 0.14\mathrm{J}$

Radius of Magnifying Glass: $r_{\text{magnifying glass}} = \frac{3.55\times 10^{-2}\mathrm{m}}{2} = 1.78\times 10^{-2}\mathrm{m}$

We can then calculate the $I_{\text{at Earth}}$ by using

$$
\begin{aligned}
I_{\text{at Earth}} &= \frac{0.14\mathrm{J}}{\pi\left(1.78\times 10^{-2}\mathrm{m}\right)^2} \\
I_{\text{at Earth}} &= 140.66\mathrm{W\,m^{-2}}
\end{aligned}
$$

6.3 P_{sun} – Power of Sun

By using

$$I_{\text{at Earth}} = \frac{P_{\text{sun}}}{\pi R^2}$$

where

Intensity of Sun Energy at Earth: $I_{\text{at Earth}} = 140.66\mathrm{W\,m^{-2}}$

Sun-earth Distance: $R = 1.496\times 10^{11}\mathrm{m}$

We can then calculate the P_{sun} by using

$$
\begin{aligned}
140.66\mathrm{W\,m^{-2}} &= \frac{P_{\text{sun}}}{\pi\cdot(1.496\times 10^{11}\mathrm{m})^2} \\
P_{\text{sun}} &= 9.890\times 10^{24}\mathrm{J}
\end{aligned}
$$

6.4 I_{sun} – Intensity of Energy Emitted by Sun

By using

$$I_{\text{sun}} = \frac{P_{\text{sun}}}{4\pi r^2}$$

where

Power of Sun: $P_{\text{sun}} = 9.890 \times 10^{24}\text{J}$

Radius of Sun: $r = 6.955 \times 10^{8}\text{m}$

We can then calculate the I_{sun} by using

$$\begin{aligned} I_{\text{sun}} &= \frac{P_{\text{sun}}}{4\pi r^2} \\ I_{\text{sun}} &= \frac{9.890 \times 10^{24}\text{J}}{4\pi \cdot (6.955 \times 10^{8}\text{m})^2} \\ I_{\text{sun}} &= 1.627 \times 10^{6}\,\text{W}\,\text{m}^{-2} \end{aligned}$$

6.5 $T_{\text{sun surface}}$ – Temperature of the Surface of Sun

By using

$$I_{\text{sun}} = \varepsilon_{\text{sun}} \sigma T_{\text{sun}}^4$$

where

Intensity of Energy Emitted by Sun: $I_{\text{sun}} = 1.627 \times 10^{6}\,\text{W}\,\text{m}^{-2}$

Emissivity of Sun: $\varepsilon_{\text{sun}} = 1$

(having the assumption that the sun is a perfect emitter)

Stefan-Boltzmann's Constant: $\sigma = 5.670 \times 10^{-8}\,\text{J}\,\text{m}^{-2}\,\text{s}^{-1}\,\text{K}^{-4}$

Finally we can calculate the T_{sun} by using

$$\begin{aligned} I_{\text{sun}} &= \varepsilon_{\text{sun}} \sigma T_{\text{sun}}^4 \\ 1.627 \times 10^{6}\,\text{W}\,\text{m}^{-2} &= 1 \cdot 5.670 \times 10^{-8}\,\text{J}\,\text{m}^{-2}\,\text{s}^{-1}\,\text{K}^{-4} \cdot T_{\text{sun}}^4 \\ T_{\text{sun}} &= 2.314 \times 10^{3}\text{K} \end{aligned}$$

7 Error Analysis

The real temperature of Sun surface is 5778K while our calculation result is 2314K, which is 60.0% smaller than the actual value. There's many possibilities that can cause such huge difference. Those may include:

- The cup is not well insulated and the heat loss is significant.

- Heat loss during the transmission from Sun to Earth is not calculated. Energy dissipation shall be considered due to the existence of atmosphere.
- Sun is not a perfect emitter by nature.
- Magnifying glass may absorb some of the energy (if you touch the glass itself it is getting warmer, indicating a heat loss there).

8 Conclusion

We have calculated $T_{\text{sun surface}}$ to be 2314K, which is having some difference as the real value. Although the calculated value is not accurately enough to be used in real research, the calculation that has been done is still quite amazing given by that the theoretical models and equations are actually working in real conditions. Physics is working! Yay! ;)