Blackbody Radiation

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1 Introduction

1.1 Purpose

Observe the blackbody emission spectra using a lambda blackbody radiation experimental system and see how changing temperatures affects the emission spectra. Use the results of the blackbody emission spectra at different temperatures to calculate an experimental value of Wein's Law and compare to the generally accepted value. Determine the value of the Stefan-Boltzmann constant using a PHeT Blackbody simulation.

1.2 References

McQuarrie, D. A.; Simon, J. D. *Physical Chemistry: A Molecular Approach*; University Science Books: Sausalito, CA, 1997.

Young, Freedman.; pages 1303 - 1308 in University Physics by Young and Freedman

Wiser, D.; *Chemistry 320 Laboratory-Blackbody Radiation*; Lake Forest College: Lake Forest, IL, 2025; pp 1-3.

Blackbody Spectrum Ver. 1.0.24 PhET Interactice Simulations: University of Colorado 2013. https://phet.colorado.edu/sims/html/blackbody-spectrum/latest/blackbody-spectrum$_e n.html$

LEOI-63 Ver. 5.0.3 Lambda Scientific Systems, Inc: 16300 SW 137th Ave, Unit 132 Miami, FL. www.lambdasys.com

1.3 Safety Information

There are no safety risks associated with this experiment.

2 Methods

The Blackbody radiation setup included a Lamda scientific blackbody radiation experimental system model number LEOI-63-E which included a power supply and a controller (Fig. 1). These were connected to a laptop running the LEOI-63 software.

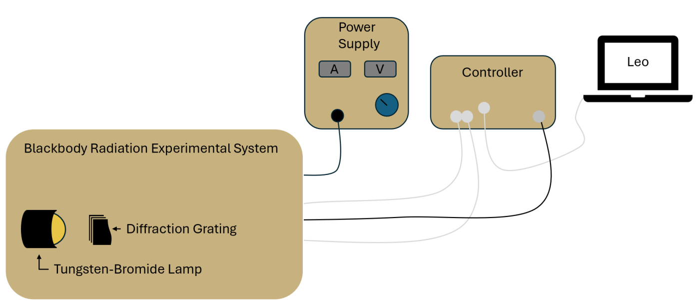

Figure 1: Cartoon of apparatus used to collected measurements to calculate Wein's Law.

The software was in energy mode with an interval of 2.0 nm over a working area of 800.0 nm to 2500.0 nm with a max of 4000.0 and a min of 0.0. It was in a working state with a NHV of 3, a gain of 6 and a times of 6. Transfer function and blackbody revise were both selected. This setup was used to calculate the value of $\frac{hc}{4.965k_B}$ in Wein's Law

$$\lambda_{max} T = \frac{hc}{4.965k_B} \tag{1}$$

The intensity and temperature used to calculate the Stefan-Boltzmann constant was collected from the PHeT interactive simulation of the Blackbody radiation simulation version 1.0.24. Temperature adjusted using the thermometer slider on the right hand side of the screen and intensity was recorded from the box in the upper center of the screen (Fig. 2). This simulation was used to calculate the value of σ in the Stefan Boltzmann equation

$$I = \sigma T^4 \tag{2}$$

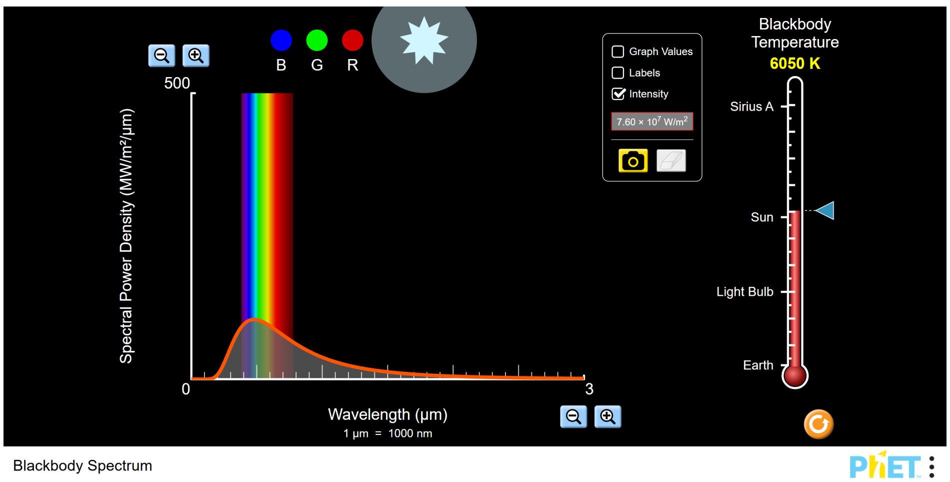

Figure 2: Snapshot of PHeT Blackbody Radiation Simulator.

3 Results/Data

3.1 Wein's Law

The max wavelength (λ_{max}) was recorded at temperatures ranging from 2940°K to 2330°K (Table 1). The LEOI-63 software collected wavelength vs energy data at each temperature (Fig. 3) and λ_{max} was collected from those graphs.

Table 1: Current, temperature and the resulting maximum wavelength from blackbody radiation experiment.

Current (A)	Temperature (K)	λ_{max} (nm)
2.45	2940	998
2.30	2860	1048
2.10	2700	1104
1.90	2560	1168
1.70	2460	1186
1.50	2330	1290

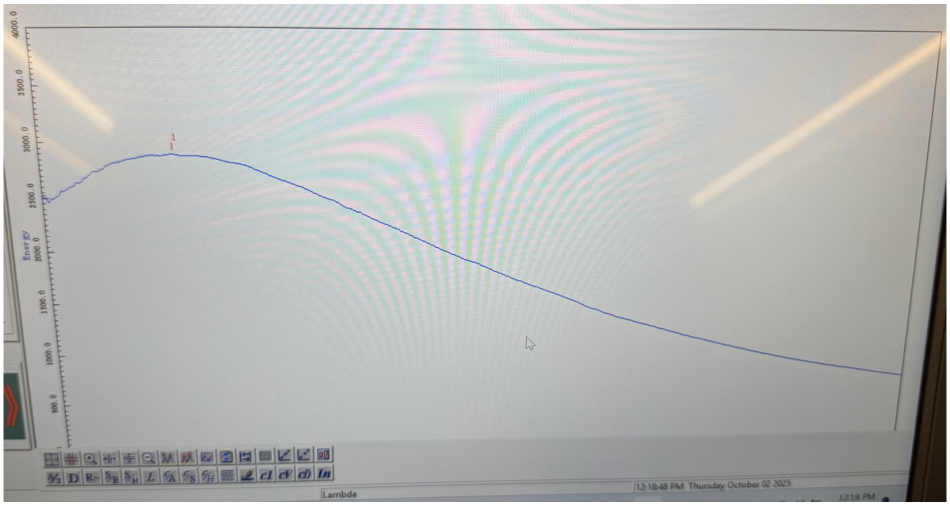

Figure 3: A graph of intensity vs frequency at a temperature of 2860°K from the LEOI-63 software.

The slope of the line (Fig. 4) was converted from the units of $\mathrm{nm} \cdot \mathrm{K}$ to $\mathrm{m} \cdot \mathrm{K}$ and the resulting value of 3×10^{-3} was compared to the accepted value of $2.898 \times 10^{-3} \mathrm{m} \cdot \mathrm{K}$ for a percent error of 3.5%.

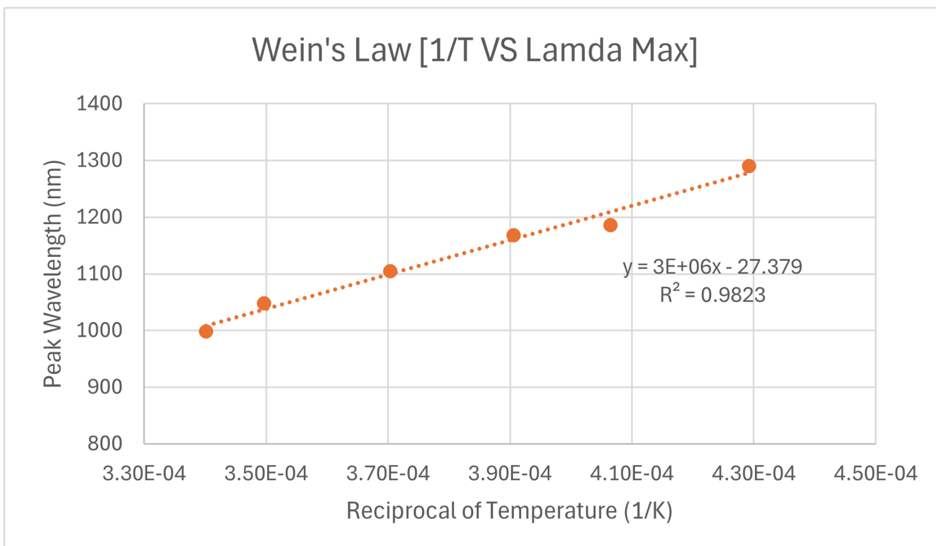

Figure 4: Graph of reciprocal temperature vs max wavelength from blackbody radiation setup that was used to estimate the Wein's Law constant.

3.2 Stefan Boltzmann Constant

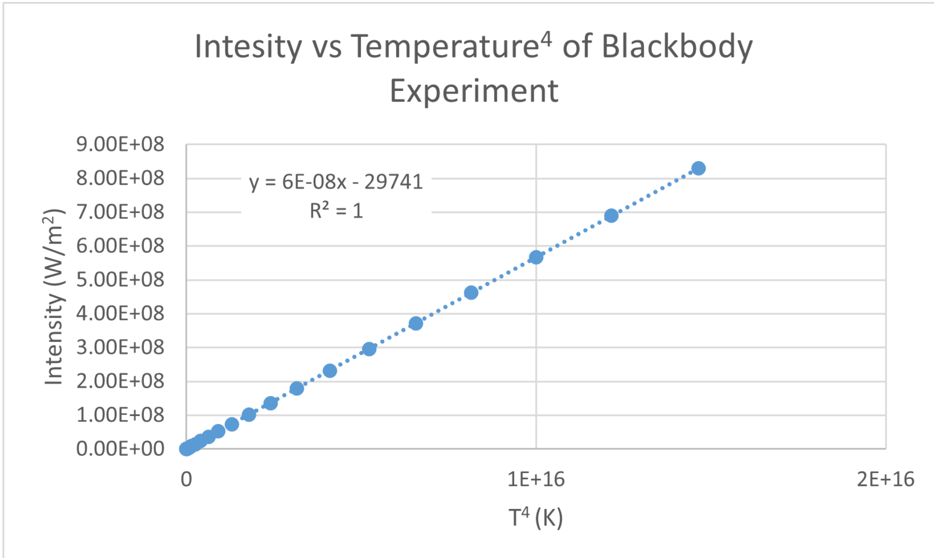

Figure 5: Graph of Temperature to the fourth power vs intensity of PHeT Blackbody simulation. The slope of the fitted line was taken as the experimental value of the Stefan-Boltzmann constant.

The PHeT simulated resulted in an experiment value of $\sigma = 6 \times 10^{-8} J/m^2 \cdot K^4 \cdot s$ (Fig. 5). When compared to an accepted value of $\sigma = 5.6705 \times 10^{-8} J/m^2 \cdot K^4 \cdot s$ from McQuarrie, there was a percent error of 5.8%. As the temperature increased, the change in intensity also increased.

4 Conclusion

We have confirmed the values of known constants for the Wein's Law constant in Wein's Law and the Stefan-Boltzmann constant in the Stefan-Boltzman Law. With a percent error of 3.5% and 5.8% respectively.