AAPT 2009 Topical Conference — Advanced Laboratories
July 23, 2009 - July 25, 2009
University of Michigan - Ann Arbor, Michigan

Parallel workshop sessions V, VII, XI, XIII

Blackbody Radiation and the Solar Photosphere Temperature

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Physics goals: (1) Verify the T^4 dependence of black body radiation with an incandescent electric lamp light source. (2) Estimate the solar photosphere temperature by using an incandescent lamp to establish pass band transmittances for six narrow band filters followed by measurements of the intensity of direct sunlight. (3) Introduce astronomical techniques such as the determination of air mass dependent attenuation corrections. (4) Use the black body spectral distribution to compute the theoretical efficiency of incandescent lamps and the power generation capability of solar cells.

Interesting tricks: (1) A high resistance incandescent electric lamp is used as a black body reference source. (2) Good narrow band filters are available over the spectral range of 450 to 950 nm.

Special Considerations: Not appropriate for winter months in northern climates.

The Planck Spectral Distribution and Measurement of the Solar Photosphere Temperature.

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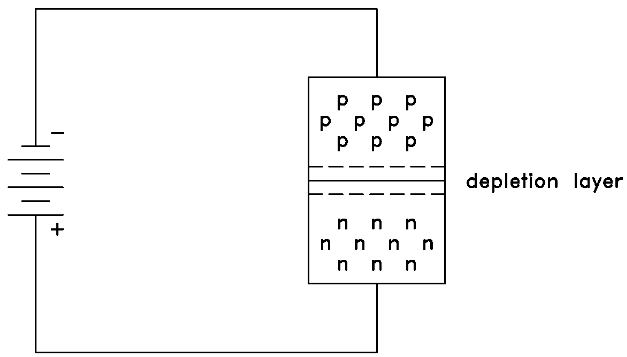
-Verify the T^4 dependence of black body radiation with an incandescent electric lamp source.
-Estimate the solar photosphere temperature by using an incandescent lamp to establish pass band transmittances for six narrow band filters followed by measurements of the intensity of direct sunlight.
-Introduce astronomical techniques such as the determination of air mass dependent attenuation corrections.
-Use the black body spectral distribution to compute the theoretical efficiency of incandescent lamps and the power generation capability of solar cells.

The Planck Spectral Distribution:

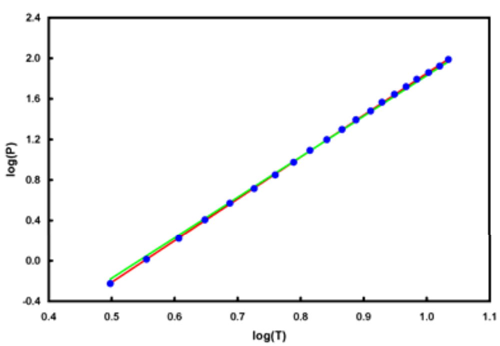
$$\frac{dI}{df} = \frac{2\pi h f^3}{c^2} \frac{1}{e^{hf/kT} - 1}$$

Photodiode:



Calibration:

-Use a photodiode and a high-resistance incandescent lamp running at a known voltage and current to calibrate the apparatus. Intensities are measured for six broadband interference filters. With the temperature known from the resistance measurements, the unknown efficiencies of the filters can be determined.



Solar Measurements:

-The apparatus is then mounted on a tripod to obtain measurements of the spectral composition of direct sunlight.
-Measurements are taken for all filters in data runs separated by several hours to estimate the variation of atmospheric extinction with solar zenith angle.

Atmospheric Extinction

-By taking solar data at different times, the atmospheric extinction, which causes less blue photons to be observed than are actually being emitted, can be determined.
-The extinction scales like $m_0/\cos(\theta)$ where m_0 is the extinction at the zenith. Fitting the experimental data determines this value.

Results:

-With the solar data, calibration coefficients, and atmospheric extinction taken into account, the only remaining variable to solve for is the temperature of the sun.

Economic Implications:

-The fraction of energy which goes into useful visible photons in an incandescent bulb can then be computed.
-The Planck distribution can be used to find the optimum bandgap to generate maximum power for a given solar flux, and that value can be used to compute the collection area to meet the nation's energy needs.