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that the radiant energy peak shifts toward shorter wavelengths with increasing temperature; thus, the spectral distribution of the light emitted by glowing sources (such as an incandescent filament or the surface of a star) can be indicated in terms of absolute temperature, also called color temperature [2]. The concept of color temperature is frequently used in photography and artificial-lighting technologies as the following experiments demonstrate.

**Experimental**

The emission spectrum of the sun, daylight at various times of the day, and artificial light sources found in the laboratory and in outdoor campus lighting were recorded using a Spectron Engineering, Inc. SE590 field-portable, data-logging spectroradiometer. A spectroradiometer measures the output (electromagnetic radiant energy) of a radiating source as a function of wavelength over a relatively narrow range of the electromagnetic spectrum [3]. Optical radiometry has found increasing use in the physical and biological sciences as a method for providing information on the changing UV component of sunlight due to the thinning of the ozone layer. Manufacturers of spectroradiometers include Spectron Engineering, Inc. (Denver, CO), PP Systems (Haverhill, MA), Optronics Laboratories (Orlando, FL), Oriel Instruments (Stratford, CT) and LI-COR (Lincoln, NB). The cost of the instruments varies widely (beginning near $5,000.00) depending on whether the spectroradiometer utilizes a scanning monochrometer or a multichannel detection scheme.

**FIGURE 1.** Spectrum of a blackbody radiator at 6000 K. The wavelength corresponding to the maximum of the curve can be determined using Wien's law.

**FIGURE 2.** Spectrum of daylight (blue curve) fit to a 5500 K Planck blackbody distribution function.
FIGURE 6. Spectra of three different types of fluorescent lamps: cool white, natural white, and Gro-Lux.

FIGURE 7. Spectrum of a low-pressure sodium vapor lamp.

**Low Pressure Sodium Vapor Lamp.** The sodium vapor lamp can often be found both inside and outside the laboratory; the low-pressure lamp is commonly used as a polarimeter reference lamp and in outdoor applications such as streetlighting. Like the fluorescent lamp, sodium vapor lamps are gas discharge lamps. They contain mercury and xenon in addition to sodium metal, which is housed in small reservoirs throughout the length of the lamp tube [8]. Radiation is produced by passing an electric current through vaporized sodium under pressure at a high temperature. Electron bombardment of the sodium metal excites the Na 3s electron to the level. A yellow photon of light is produced when the excited electron returns to the ground state. Because the light emission results from a discrete transition, a line spectrum results (see Figure 7). The visible light consists of the Na D lines and is nearly monochromatic, yellow light. Because the lamp output is yellow light only, all colors illuminated by the lamp appear as different shades of gray or brown except for yellow objects; thus, the lamp is said to provide poor color rendering [8]. Students can note this by