The greenhouse effect: radiant transmittance of glass

By J.H. Taylor

Editor's note: This is the eighth installment in a series of lecture demonstrations on radiation exchange. The author teaches in the Physics Dept. at Rhodes College in Memphis, Tenn. The October issue will cover the surface temperature of the planet Earth.

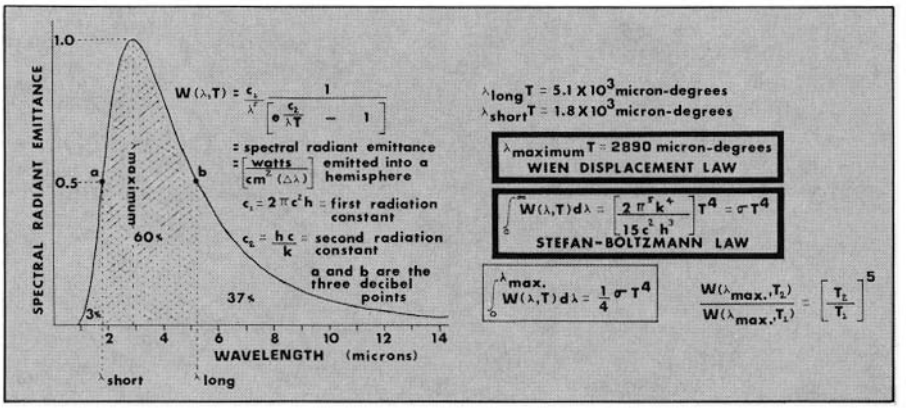
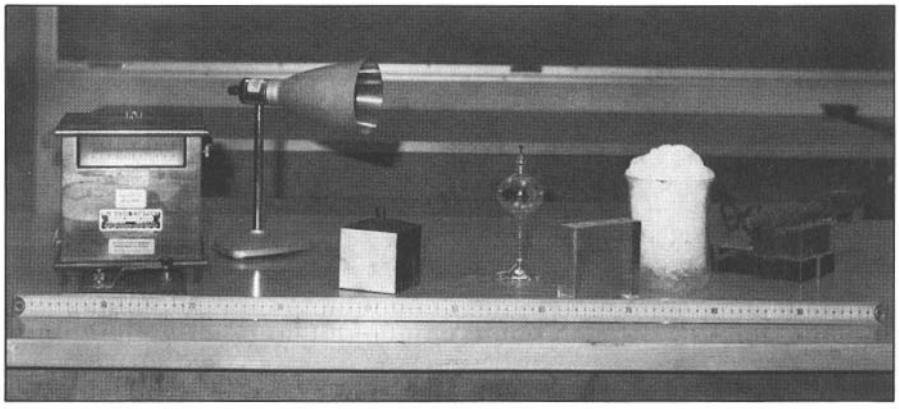


FIGURE 1. Planck Radiation Law.



Photograph of the apparatus used by the author to demonstrate radiation exchange.

The equipment shown in the photo is used to introduce students to the theory of the Greenhouse Effect. With the energized soldering iron placed several feet in front of the radiation thermopile, one obtains full-scale deflection on the galvanometer. A lab jack is then used to support a piece of high quality optical glass (about 1" thick) that is large enough to completely cover the reflecting cone associated with the radiometer. The students observe the galvanometer deflection return to zero, indicating that glass does not transmit infrared. In other words, radiation beyond about 2 μm is absorbed by the glass. This observation is very critical in a discussion of the Greenhouse effect.

Viewing Fig. 1 on the Planck Radiation Law, imagine such a curve drawn for an object with a temperature of 6000°C (approximately the surface temperature of the Sun). The peak of such a curve would lie in the visible region of the spectrum. In fact, almost 60% of the radiation from the Sun lies in the visible.

Since glass is transparent in the visible, the majority of the radiation from the Sun gets through the greenhouse glass and is absorbed by the plants and other contents inside. The temperature of the objects in the greenhouse is about 23°C or roughly 300 K. Invoking the Wien Displacement Law, we calculate that the peak radiation from such objects will take place at about 10 μm. However, since glass is not transparent at 10 μm, the radiation from the objects inside the greenhouse is absorbed by the glass. The temperature of the glass will rise and the glass will radiate more. Part of this radiation is toward the outside of the greenhouse, part of it is toward the inside. It is this latter radiation that helps to hold up the temperature inside.