How We Use a Photometer to Measure the Sun's Luminosity

A **photometer** is a device to measure the apparent brightness of a source of light, by comparing the amount of light falling on the device from the source with the light from a source with known output. In this experiment, we will use a simple photometer made with two blocks of paraffin wax and which uses your eyes as the detectors. The two blocks are separated by a sheet of aluminum foil and held together by rubber bands. (See Figures 1 and 2.)

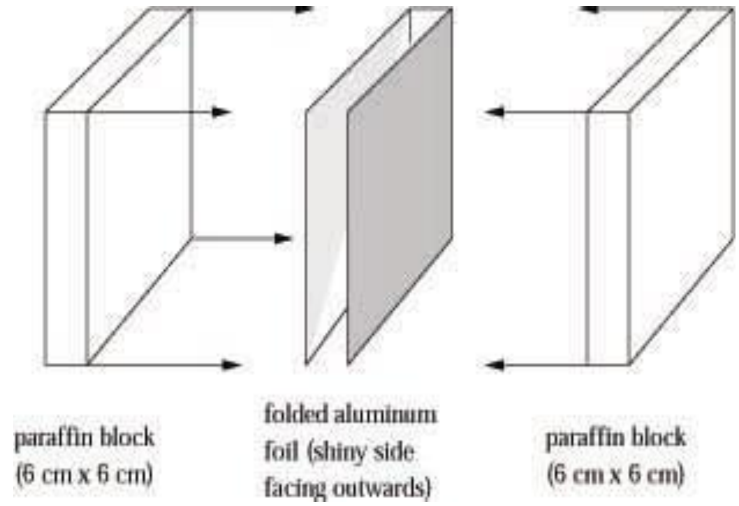


Figure 1: Photometer Assembly

When a light source shines on one side of the photometer, the paraffin block on that side glows. The closer the light is to the photometer, the brighter the wax block will appear to be. The apparent brightness (I) of the paraffin block is determined by the inverse square law

$$I = \frac{kL}{4\pi\, d^2} \qquad (2)$$

where d is the distance from the light source to the photometer, measured in centimeters, L is the luminosity of the light bulb in Watts and k is a fudge factor to account for things like absorption in the paraffin.

The block on the opposite side remains dark because the light is reflected by the aluminum foil and cannot pass through. (See Figure 3.) If another light source is placed on the opposite side of the photometer, then that side will also glow and the apparent brightness of that block can also be calculated using the inverse square law.

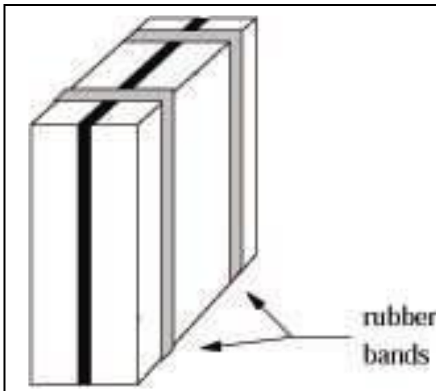


Figure 2: A completed photometer

Now suppose that we want to measure the luminosity of Sun and we know how far it is from the photometer. If we point the one side of the photometer toward the Sun, it will glow. If we place a light bulb with a *known* luminosity on the other side, then that side of the paraffin block will also glow, but not with the same brightness. However, if we move the light bulb so that the apparent brightnesses of both sides of the photometer are the *same*, then we can calculate the luminosity of the Sun. (See Figure 4.)

When the two sides of the photometer glow with the same brightness, the apparent brightness of the paraffin on the light bulb side is equal to the solar output, or $I = I_{sun}$, where I is the apparent brightness from the light bulb and I_{sun} is the apparent brightness of the Sun. Substituting the inverse square law into this equation we find that

$$\frac{L}{4\pi\, d^2} = \frac{L_{sun}}{4\pi\, D_{sun}^2} \qquad (3)$$

where L and L_{sun} are the luminosities of the light bulb and the Sun, respectively, and d and D_{sun} are the distances of these two sources from the photometer. Assuming the paraffin blocks on either side of the aluminum foil are similar, the fudge factor, k, cancels out. We already know L and D_{sun}, and we can measure d, so this equation can be manipulated to give the luminosity of the Sun, L_{sun}.

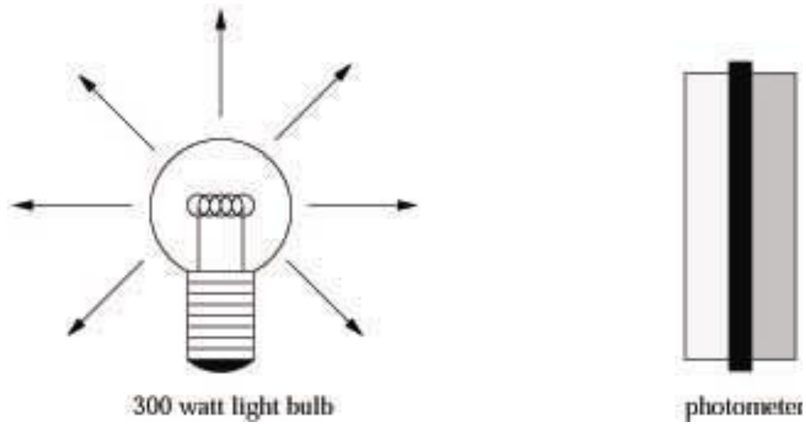


Figure 3. The side of the paraffin facing the light glows.

The experiment works better if the paraffin block is partially surrounded by a baffle to keep stray sunlight from reaching it. You can use pieces of black cardboard to make a baffle, as indicated in Figure 4.

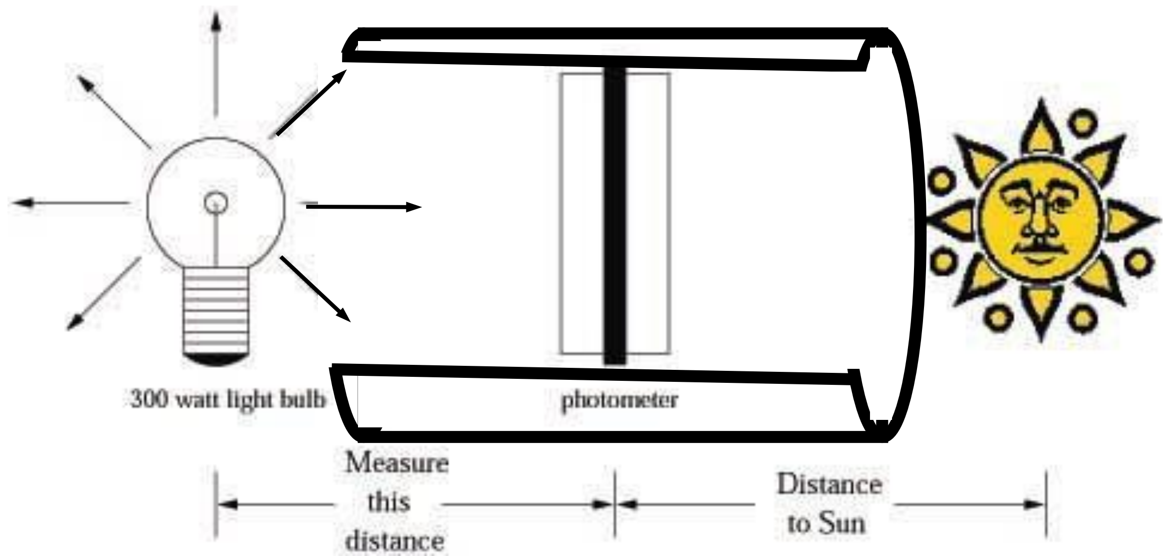


Figure 4. Comparing the brightness of the Sun to a 300-Watt light bulb.

NatSci102 (Prof. Rieke) **Name__________________**

This sheet is to be turned in along with the rest of the homework assignment.

Measuring the Sun's Luminosity

1. Each group of students will be given a 300-watt bulb, an extension cord, a photometer, a ruler, and a large piece of black poster board.

2. Plug in the bulb and turn it on.

3. Hold the photometer between the Sun and the bulb with the bulb's filament parallel to the face of the photometer. Hold the other face of the photometer towards the Sun (see Figure 4). One of you should hold the cardboard baffle around the paraffin block.

4. Move the photometer toward and away from the Sun, stopping when the two sides have the same apparent brightness. The color difference between the Sun and the bulb will cause a color difference on either side of the paraffin. Just keep in mind that the apparent brightness on both sides of the paraffin should be similar in intensity rather than color.

5. Hold the photometer steady while a member of your group **measures the distance *in centimeters* between the bulb *filament* and the *aluminum* in the photometer**. Make observations as carefully and consistently as you can. Record each measurement in Table 1.

6. As a check on your first value, repeat the above step four more times, *switching responsibilities with your group members each time*. Also, try reversing the paraffin block so the sun and light bulb shine on the opposite sides from where you started. Again, record your measurements in the table below. If there is a major discrepancy between any of the measurements (more than a couple of centimeters), then additional measurements are needed. On the other hand, if the five measurements are fairly close in value, average them to yield a single measurement.

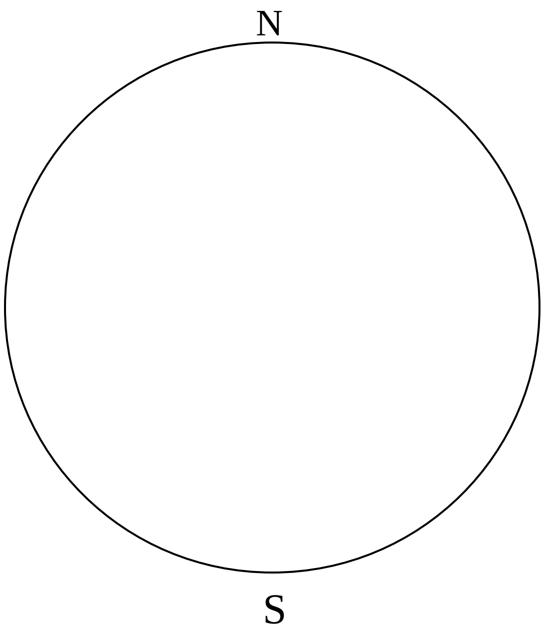
	Bulb distance, *d* **(cm)**
Measurement #1	
Measurement #2	
Measurement #3	
Measurement #4	
Measurement #5	
Average Value =	

Table 1: Photometer measurements.

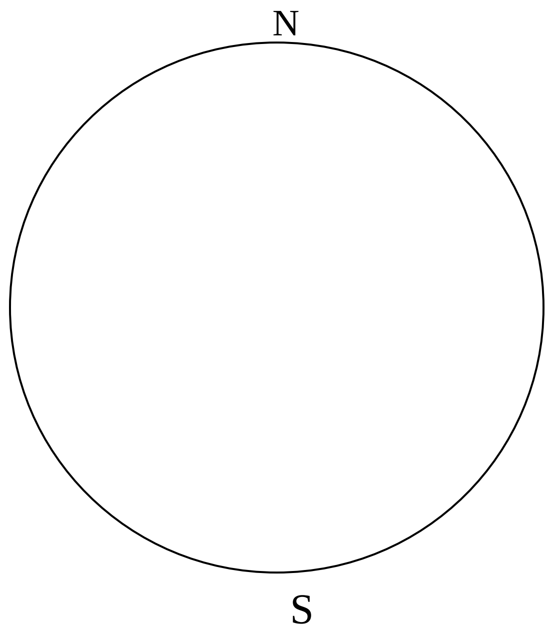
Features on the Sun

1. Draw the features on the Sun as you see them through each telescope.
**Note: The Celestron images are flipped left to right compared to the SOHO images.

SOHO X-ray Image



Celestron Telescope



Discuss any similarities or differences between the images of the Sun you have recorded above. Suggest reasons for this.