PHOTOELECTRIC EFFECT

Objective

To determine Planck's constant from the photoelectric effect.

Equipment

Photoelectric effect apparatus, wood blocks, voltmeter, high intensity mercury arc lamp and a set of filters.

Background

The emission of electrons when light is shown on a metal is known as the photoelectric effect. Einstein explained the photoelectric effect by postulating that light waves are made of individual packets of energy called photons. Each photon carries energy hf, where h is Planck's constant and f is the frequency of the photon. If the photon is above a certain threshold frequency when it strikes a metal it can cause an electron to be ejected from the surface. The maximum kinetic energy of this electron is given by

$$E = hf - W$$

where E is the maximum kinetic energy and W is the work function of the metal. If a large enough potential is supplied to the photoelectric effect apparatus, the photoelectric current can be decreased to zero. The potential where the photoelectric current becomes zero is called the stopping potential. The relation between the stopping potential and the maximum kinetic energy is

$$E= e*V$$

where V is the stopping potential and e is the electron charge.

Procedure

Step 0: For this lab you will prepare an **individual** data sheet. Please write your last name and first name on this paper.

Step 1: Making the circuit

- Connect a digital voltmeter to the red and black banana jacks on the top of the panel of the case. The banana jacks are connected across the photodiode and measure the stopping potential across the tube. A digital voltmeter is best for this measurement.

Step 2: First zero adjust

- Turn the voltage adjust down to 0 (counter clock wise).

- Place the filter marked 436nm over the phototube aperture.

- Turn on the Photoelectric apparatus.

- Looking at the current reading on the Photoelectric apparatus, adjust the "Zero Adjust" so that the current value reads zero.

Step 3: Adjusting the distance between the lamp and the apparatus

- Set up the Photoelectric effect apparatus so that the aperture in front of the photodiode faces the mercury lamp (as shown in the picture).

- **Starting with a large distance between the lamp and the apparatus**, turn on the Mercury lamp.

- Adjust the distance so that the meter is approximately 10 nA on the scale. Make sure that the radiation is striking the center of the photodiode. The reading on the output meter is helpful in making the adjustment: Move the apparatus from side to side until the reading is a maximum.

Step 4: Fine zero adjust

All photocells have some dark current which affects the "zero" done in step 2. A true zero can be obtained with the following procedure:

- Turn the voltage knob (clock wise) high enough to stop the current.

- Adjust the "Zero Adjust" so that the meter reads zero.

It is important to maintain the same background of light during the whole experiment. Also, the zero adjustment should be frequently checked during the measurements.

Step 5: Measure and record the output current as a function of the voltage across the tube. **Report your data in a table in your data sheet.** As the voltage increases, fewer and fewer electrons have enough energy to leave the cathode, and the current drops. **The critical point on the curve is the voltage at which the current just falls to zero.**

Step 6: Measure the voltage for zero current five times, turn the voltage off and check the "Zero Adjust" between each measurement. Make sure the apparatus always remains zeroed correctly. Note that the curve remains at zero for stopping values higher than the critical value: **The value of interest is that value when the current just reaches zero, don't record voltages past this point.** Compute the average of your five measurements. **Record your data in your data sheet.**

Step 7: Change the filter to the one marked 546nm. Repeat the measuring procedure (steps 3-6). The stopping potential should be less than that of the previous filter. **Record your data in your data sheet.**

Step 8: Change to no filter. This will allow the 406nm mercury line to fall upon the phototube. Repeat the measuring procedure. The no-filter frequency is 7.38 x 10 14 Hz. **Record your data in your data sheet.**

Individual data sheet

Record all your data (step 5 to 8). (Please write your last name and first name on this paper)

Graphs and Diagrams

1. From step 5 of the procedure, plot the anode current versus the potential across the tube (measured with the voltmeter). Make a separate graph for each filter (frequency) used. Using the critical point of each graph, find the corresponding value of the stopping potential.

2. **From step 6 of the procedure**, plot the average stopping potential versus the frequency of light.

Questions and Calculations

1. From the first set of graphs, find the stopping potential for each frequency of light.

2. From step 6, average all the stopping potential measurements for a given frequency of light to find the best estimate of this quantity.

3. From graph 2, find Planck's constant and compare this value with the accepted value.

4. Do all electrons ejected from the metal surface have the same kinetic energy? Is this important for the interpretation of this lab?