

Experiment

Verification of Einstein's Equation

1. OBJECTIVE

- 1.1. Verification that light beams consist of quanta or photons.
- 1.2. Determination of Planck's constant h and the work function w_0 .

2. EINSTEIN'S EQUATION OF PHOTOELECTRIC EFFECT

$$h\nu = h\nu_0 + eV_s.$$

or

$$V_s = \frac{h}{e}(\nu - \nu_0) \quad (6)$$

This equation was introduced by Einstein in order to explain the photoelectric effect. In this experiment the validity of Einstein's equation is validated. Part A selects two spectral lines from a mercury light source and determines the maximum energy of the emitted photoelectrons as a function of the intensity. Part B selects different spectral lines and investigates the maximum energy of the photoelectrons as a function of the colour of the light. In part C, planck's constant (h) and the work function (w_0) of the target material, are determined.

3. APPARATUS

DC Power Supply I (Constant Voltage) (SE-6615) - DC Current Amplifier (SE-6621)- Mercury Light Source (SE-6608)- Track, 60 cm and required cables - Photodiode Enclosure with tube having a filter wheel and aperture selection ring .

4. EXPERIMENTAL SETUP

1. The standard setup for this experiment is shown in Figure (1). Put the Mercury Light Source and Photodiode Enclosure on the Track(60 cm) ,Turn on the power of the Mercury light source. Check the alignment of the light source and the Aperture of the Photodiode Enclosure by looking at the light shining on the filter wheel..

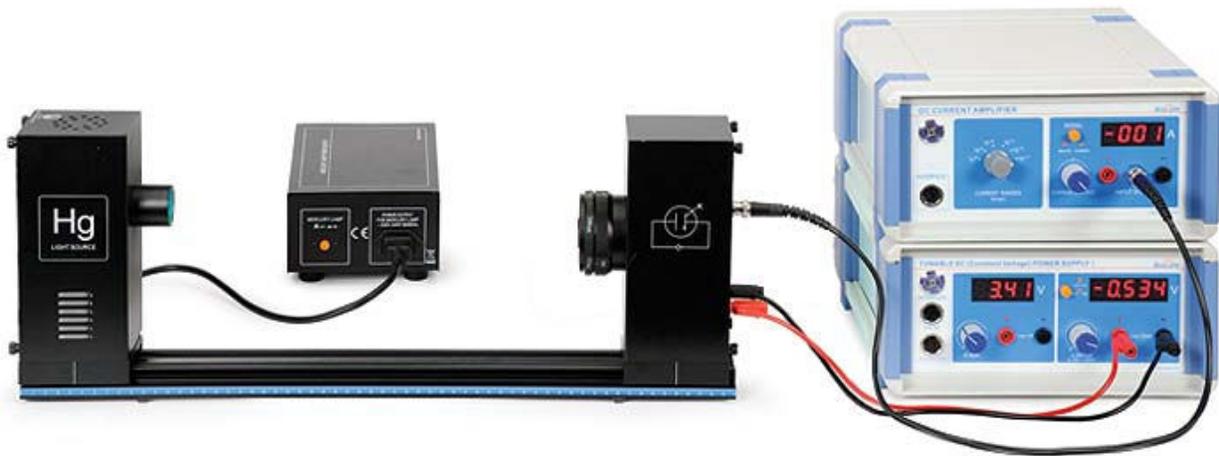


Figure 1: Experimental setup

2. Connect the photodiode with the DC Power Supply I and the DC Current Amplifier as shown in Figure 1. Adjust the DC Power Supply output voltage from -4.5 V to 30 V and the DC current Amplifier to 10^{-12} A.

3. Use the filter wheel and aperture selection ring Figure 2 to select the colour that will enter to the photodiode and the size of the aperture (the amount of light that will enter to the photodiode).
4. Change the input voltage to the Photodiode (by rotating the button of the DC Power supply and observe the input voltage on the digital display) and observe the corresponding current (the digital display on the DC current amplifier).
5. For safety, do not touch the Mercury light source (it is very hot while in use).



Figure 2: filter wheel and aperture selection ring

5. PROCEDURE

5.1 PART (A)

1. Adjust the filter wheel so that only one colour enters to the photodiode.
2. Set the aperture size to 8 Φ
3. Adjust DC power supply voltage until the current is equal to zero and record the voltage in Table 1.
4. Change the Aperture size by rotating the ring in the photodiode to 4 Φ and repeat step 3.
5. Change the Aperture size by rotating the ring in the photodiode to 2 Φ and repeat step 3.
6. Repeat the procedure using a second colour from the spectrum.

5.2 PART (B)

1. You can easily see five colour filters on the photodiode. Adjust the filter so that only one colour enters the photodiode, and set the aperture size to 8Φ .
2. Adjust DC power supply voltage until the current is equal to zero and record the voltage in Table 2.
3. Repeat the process for each colour filter.

5.3. PART (C)

1. Adjust the filter wheel so that only one colour enters to the photodiode.
2. Set the aperture size to 8Φ
3. Adjust DC power supply voltage to a constant voltage
4. Change the Aperture size by rotating the ring in the photodiode to 4Φ and repeat step 3 and observe the current.
5. repeat for an Aperture size by rotating the ring in the photodiode to 2Φ and repeat step 3.
6. Repeat the procedure using a second colour from the spectrum.

6. RESULTS

6.1. PART (A)

Table 1

Selected Colour Name	Aperture size	Stopping Potential (V)
Yellow	8 Φ	
	4 Φ	
	2 Φ	
Green	8 Φ	
	4 Φ	
	2 Φ	

1. Describe the effect that passing different amounts of the same coloured light has on the stopping potential.
2. Explain why there is a slight drop in the measured stopping potential as the light intensity is decreased.

6.2. PART (B)

Table 2

Spectral Line Colour	Wavelength λ (nm)	Frequency (Hz)	Stopping Potential (V)
Yellow	578	5.19×10^{14}	
Green	546	5.49×10^{14}	
Blue	436	6.88×10^{14}	
Violet #1	405	7.41×10^{14}	
Violet #2	365	8.22×10^{14}	

- Describe the effect that different colours of light have on the stopping potential and thus on the maximum energy of the photoelectrons.
- Define whether this experiment supports a wave or a quantum model of light based on your laboratory results.
- Determine the wavelength and frequency of each spectral line. Plot a graph of the stopping potential versus the wavelength, and graph of the stopping potential versus frequency. The latter is a straight line. Determine the slope and y-intercept. Interpret the results in terms of the $[h/e]$ ratio and the $[w_0/e]$ ratio.

6.3. PART (C)

ACCELERATING POTENTIAL V=

Table 3

Selected Colour Name	Aperture size	Current (A)
Yellow	8 Φ	
	4 Φ	
	2 Φ	
Green	8 Φ	
	4 Φ	
	2 Φ	

- Describe the effect that passing different amounts of the same coloured light has on the flowing current.

Explain why the current decrease as the light intensity is decreased.

