Wroclaw University of Science and Technology

GENERAL PHYSICS
LABORATORY REPORT

Theme of class: EXTERNAL EXAMINATION OF THE PHOTOELECTRIC

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1 Introduction

1.1 Theory

Current saturation - it is what we call when no more current can be produced by a device(semiconductor or magnetic) if we vary the voltage or amount of light shun onto it. A physical reason will stop this from happening, and it varies on circumstance as to why this might happen.

The external photoelectric effect is a phenomenon in which electrons are ejected from the surface of a material when light of sufficient energy is incident upon it. The effect was first observed by Heinrich Hertz in 1887, and it is a key concept in the understanding of the interaction between light and matter.

The theory of the external photoelectric effect is based on the idea that light consists of packets of energy called photons. When a photon of sufficient energy strikes an atom or molecule in a material, it can transfer its energy to an electron in the material, causing the electron to be ejected from the surface. The minimum energy required for this to occur is known as the material's work function, which is the energy required to remove an electron from the material's surface.

The external photoelectric effect is described by the photoelectric equation, which relates the energy of the incident photons, the work function of the material, and the maximum kinetic energy of the ejected electrons. The equation is given by:

$E_{\mathrm{photon}} = \phi + \frac{1}{2}mv_{\mathrm{max}}^2$

where E_{photon} is the energy of the incident photon, ϕ is the work function of the material, m is the mass of the ejected electron, and v_{max} is the maximum velocity (and thus kinetic energy) of the ejected electron.

The photoelectric effect is an important phenomenon in many areas of science and technology, including solar energy conversion, semiconductor electronics, and imaging technologies. It has also played a key role in the development of quantum mechanics, as it provided early evidence for the wave-particle duality of light.

1.2 Equipment

The equipment used in this experiment included:

- Monochromator
- DC ammeter
- DC voltmeter
- Illuminator
- DC power supply for the illuminator
- Photocell power supply

2 Experiment

2.1 Measurements of the spectral characteristics of the photocell photocurrent

In this exercise we are going to take measurements of the spectral characteristics of the photocell photocurrent.

λnm	$u_\lambda$nm	I µA	u_I µA		λnm	$u_\lambda$nm	I µA	u_I µA
370	1.2	0.2	0.116		540	1.2	3.5	0.119
375	1.2	0.3	0.116		545	1.2	3.3	0.119
380	1.2	0.3	0.116		550	1.2	3.2	0.119
385	1.2	0.4	0.116		555	1.2	2.9	0.118
390	1.2	0.5	0.116		560	1.2	2.8	0.118
395	1.2	0.7	0.117		565	1.2	2.6	0.118
400	1.2	0.8	0.117		570	1.2	2.3	0.118
405	1.2	0.9	0.117		575	1.2	2.1	0.118
410	1.2	1	0.117		580	1.2	1.9	0.118
415	1.2	1.1	0.117		585	1.2	1.7	0.117
420	1.2	1.3	0.117		590	1.2	1.3	0.117
425	1.2	1.4	0.117		595	1.2	1	0.117
430	1.2	1.5	0.117		600	1.2	0.7	0.117
435	1.2	1.7	0.117		605	1.2	0.5	0.116
440	1.2	1.9	0.118		610	1.2	0.3	0.116
445	1.2	2	0.118		615	1.2	0.2	0.116
450	1.2	2.1	0.118		620	1.2	0.2	0.116
455	1.2	2.3	0.118		625	1.2	0.1	0.116
460	1.2	2.4	0.118		630	1.2	0.1	0.116
465	1.2	2.7	0.118		635	1.2	0	0.116
470	1.2	2.8	0.118		640	1.2	0	0.116
475	1.2	3.1	0.119		645	1.2	0	0.116
480	1.2	3.3	0.119		650	1.2	0	0.116
485	1.2	3.4	0.119		655	1.2	0	0.116
490	1.2	3.5	0.119		660	1.2	0	0.116
495	1.2	3.7	0.119		665	1.2	0	0.116
500	1.2	3.8	0.119		670	1.2	0	0.116
505	1.2	3.9	0.119		675	1.2	0	0.116
510	1.2	3.9	0.119		680	1.2	0	0.116
515	1.2	3.9	0.119		685	1.2	0	0.116
520	1.2	3.9	0.119		690	1.2	0	0.116
525	1.2	3.8	0.119		695	1.2	0	0.116
530	1.2	3.8	0.119		700	1.2	0	0.116
535	1.2	3.6	0.119					

Table 1:

Calculations

$$u(\lambda) = \frac{2}{\sqrt(3) =} 1.2\,\mathrm{nm} \tag{1}$$

$$u(I) = \frac{0.15\,\% \cdot 0.2 + 20 * 0.01}{\sqrt(3)} = 0.116\,\mu\mathrm{A} \tag{2}$$

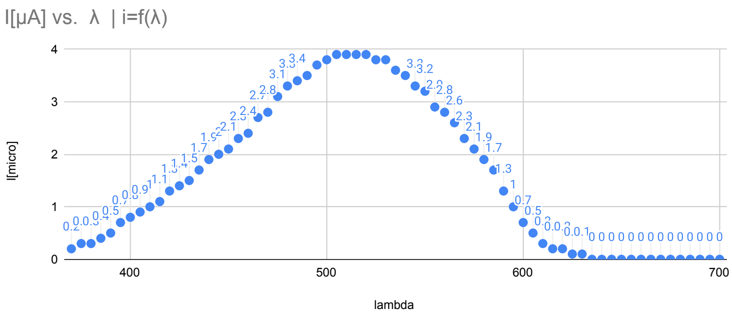

Figure 1: Estimating the value of the treshold wavelength

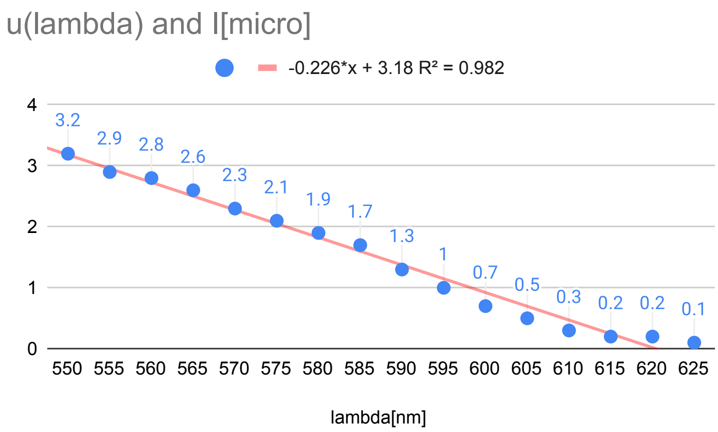

Figure 2: Approximate the long-wave edge of the spectral characteristic

a	u(a)	b	u(b)	$\lambda_o nm$	$u_c(\lambda_o) nm$
-0.226	0.0019	140	1.1	619.5	7.1

Calculations

$$\lambda_o = -\frac{b}{a} = -\frac{140}{-0.226} = 6.19.5nm \tag{3}$$

$$u_c(\lambda_0) = \sqrt{(-\frac{1}{a} \cdot u(b))^2 + (\frac{b}{a^2} \cdot u(a))^2} \approx 7.1nm \tag{4}$$

λ_0 [nm]	u(λ_0) [nm]	W [J]	u_c(W) [J]	$E_k$max [J]	uc(Ekmax)[J]
619.5	7.1	3.21E-19	0	-3.20E-19	0

Calculations

$$W = \frac{h \cdot c}{\lambda_0} = 3.21 \times 10^{-19}\,\mathrm{J} \tag{5}$$

2.2 Measurements of current-voltage characteristics

In this exercise are going to take measurements of the current-voltage characteristics. Measure the current-voltage characteristics of the photocell.

V [V]	u(U) [V]	I [µA]	u(I) [µA]
0.2	0.00106	0.1	0.019
1.4	0.00729	0.8	0.024
2.2	0.01145	1.1	0.027
3.1	0.01612	1.6	0.031
4	0.0208	1.9	0.033
5	0.026	2.2	0.036
6	0.03119	2.5	0.038
7	0.03639	2.7	0.04
8.3	0.04314	3	0.042
9	0.04678	3.1	0.043
10.3	0.05354	3.3	0.044
12	0.06237	3.5	0.046
14.4	0.07484	3.7	0.048
16	0.08315	3.7	0.048
18	0.09355	3.7	0.048
20.2	0.10498	3.7	0.048
22	0.11433	3.7	0.048
24.1	0.12524	3.7	0.048
26	0.13512	3.7	0.048
28	0.14551	3.7	0.048
30.1	0.15642	3.7	0.048
40.1	0.20838	3.7	0.048
50.2	0.26086	3.7	0.048
60	0.31179	3.7	0.048
70	0.36375	3.7	0.048
80	0.41571	3.7	0.048
90	0.46767	3.7	0.048
100	0.51963	3.7	0.048
110	0.57159	3.7	0.048
115	0.59757	3.7	0.048

Table 2: $\lambda = 520nm$

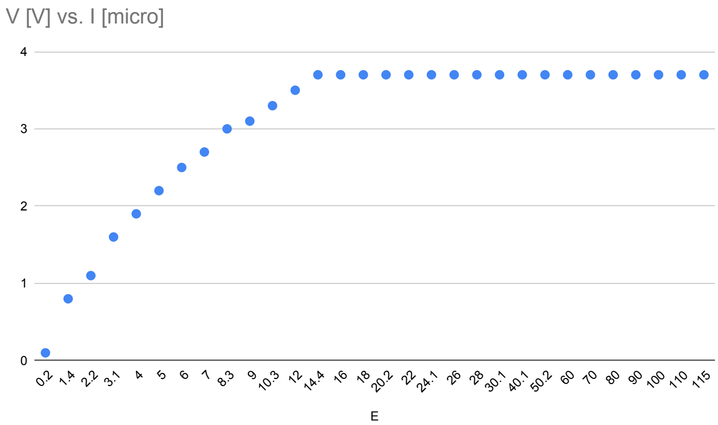

Figure 3: Light intensities used in the experiment

Is [µA]	u(Is) [µA]
3.700	0.048

Table 3: Estimated current saturation. (We assume that is is the value of current at the polarization of approximately 115V).

In our exercise, the graph made of our measurements is similar to the graph we have found in instruction, so we can assume that our measurements were made correctly.

3 Conclusion

In this physics lab, the aim was to study the external photoelectric effect. The experiment involved determining the I-V characteristic of a photovoltaic cell, measuring the spectral characteristic of the photocurrent, and finding the red limit of the photoelectric effect. The experimental setup consisted of a monochromator, an illuminator, a stabilized illuminator power supply, a photovoltaic cell power supply, a voltmeter, and a DC ammeter. The results were obtained by adjusting the wavelength using the monochromator, and the power output of the illuminator was varied to obtain different levels of illumination. The voltage and current output were recorded, and the values of the dark current were also measured. This experiment helped us understand the principles of the photoelectric effect and its applications in various fields. The results obtained provide valuable insights into the behavior of photovoltaic cells and their potential uses in energy generation.