Photoeffect

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Introduction

Under the right circumstances light can be used to push electrons, freeing them from the surface of a solid. This process is called the photoelectric effect (or photoelectric emission or photoemission), a material that can exhibit this phenomena is said to be photoemissive, and the ejected electrons are called photo- electrons; but there is nothing that would distinguish them from other electrons. All electrons are identical to one another in mass, charge, spin, and magnetic moment.

The photoelectric effect was first observed in 1887 by Heinrich Hertz (1857?1894) during experiments with a spark-gap generator ? the earliest form of radio re- ceiver. The photoelectric effect posed a significant challenge to the study of optics in the latter portion of the 1800s. It challenged the classical wave theory of light, which was the prevailing theory of the time. It was the solution to this physics dilemma that catapulted Einstein into prominence in the physics community, ultimately earning him the 1921 Nobel Prize.

Theoretical Tasks

- What is the internal photoelectric effect? What applications does it have? What is the external photoelectric effect? Where can one apply it?
- Experimental determination of Planck's constant h: What are possible experimental error sources and how can one avoid them as best as possible?
- The photoelectric effect is described by assuming that light is propagating in the form of electromagnetic waves: What phenomenon can be expected in consideration of
  - the wave model
  - the quantum model.
- What value does the contact potential of the used materials of the Leybold-photocell have? Will the work function of the electrons be affected by it?
- How does the energy distribution of photoelectrons depend on the temperature?
- What factors does the stopping potential depend on?
- What have a light emitting diode (LED) and the photoelectric effect in common?

Experimental Tasks

- Construction of the experimental arrangement with Leybold Photocell: Pay attention to the correct cabling (Abbildung 0.1), which is mandatory for a good measurement (ground!). It is advantageous to illuminate only the photocathode (i.e. with lenses, apertures) and switch off the light in the room.

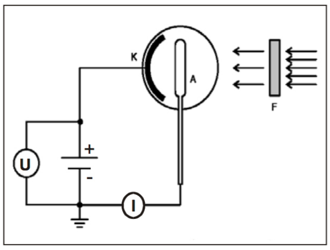

Abbildung 0.1: Pay attention to the correct cabling.

  - Determine the Planck's constant h.
  - Determination of the work function W_a.

  Compare these values with literature and consider possible error sources.

- Measure the necessary stopping potential for completely braking of photoelectrons as a function of the wavelength and the intensity of the light (stopping potential method).
- Estimate graphically the upper cut-off wavelength, at which there are still photoelectrons triggered for the Leybold-photocell.
- Take the full characteristic curve of the photocell at various light wavelengths. Can you calculate from this the energy distribution of the photoelectrons? Is there any other method, to measure such a distribution? What will change in the determination of h, if additional scattering light is added to the photocell?

- Measure the characteristic current-voltage curve of each LED.
- Determine the voltage at which the LEDs start emitting light and determine h (resp. $\frac{h}{e}$) from this.

Advice

Please read the instructions of halogen lamp, photocell, picoampermeter and microvoltmeter carefully before beginning the experiment. Do not touch the broadband filters! Please handle the photocell and the prism with care.
Do not apply more than 3V onto an LED.
Please report any damages or error corrections to the assistant, so that the following students may find better conditions. Suggestions about the experiment itself are always welcome and they will be implemented if possible.

Literature

[1] Bergmann, Schäfer: Lehrbuch der Experimentalphysik: Band 3: Optik. (ODA 114)

[2] M. Garbuny: Optical Physics. Academic Press, New York 1965 (TDA 144)

[3] H. Paul: Photonen, Experimente und ihre Deutung. Akademie Verlag, Berlin 1985 (TDE 113)

[4] H. Simon und R. Suhrmann: Der lichtelektrische Effekt und seine Anwendungen.
Springer Verlag, Berlin 1958 (TDE 116)

[5] M. v. Ardenne, G. Musiol, S. Reball, Effekte der Physik und ihre Anwendungen.
Harri Deutsch Verlag, Thun 1990

[6] H. Haken und H.C. Wolf: Atom- und Quantenphysik. Springer Verlag, Berlin 1990