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New technologies to detect electron beam signals

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Abstract

Electricity and electronic devices are playing an overwhelming role in human society. As physical studies are extending the applications of electric currents in metals, electrolyte liquids, gases, vacuum, semiconductors, or superconductors, this paper focuses on the electronic current beam in the vacuum. To this aim, experiments with cathode ray tubes and cathode ray balloons are conducted in our physics lab classes. Therefore, important observations and measurements are accomplished, concerning several physical qualities and quantities. As the electron beam is being visibly observed, electric signals are detected from the beamed target. The observed qualities are assembled and listed, whilst data from the measured quantities are displayed using table and graph plotting.

Keywords: electron, beam, current, signal, sensor, interface.

Introduction

The discovery of the electron started a new era in physics, and technology as well [1][2]. The study of electron – based atomic structures helped and ruled the physical reconstruction of chemical materials from a micro world perspective. The application of electronic practical theories helped device engineering to advance further with electronic circuits. As a result, new achievements are recorded in both traditional and modern science [3]. Consequently, electronic studies are introduced in physics education at several academic levels, from elementary to graduate and postgraduate [4]. Taking into account that physics is an experimentally – oriented science, class electronic theories have all demanded for proper experiments in support.

Although this is a tough area, constructors have been able to provide physics classes and laboratories with devices useful to pure electronic experiments, helping teachers and students with their research and educational activities. Cathode ray tubes, cathode ray balloons, cathode ray electronic – millwheels are some of the electronic devices produced with the goal to demonstrate the spectacular reality of the electron. Furthermore, these devices can be successfully used to study some properties of the electron ray beams.

This kind of studies have also proved to be efficient to other people with poor scientific background, but, yet, eager to mystical knowledge.

Theory

Physical research has demonstrated that some materials emit electrons like negative carriers, when under certain physical conditions, such as heat, light, or else [5]. An additional electric field causes these electronic carriers to move away from the possessing material.

In the case of cathode ray balloons, thermal heat filament is applied to release electrons from the cathode material, and, hence, the phenomena of thermionic emission is observed [6][7]. Freed electrons are pushed away from the negatively charged cathode to the positively charged anode and producing like such an electronic current. The electric source removes the newly arrived electrons from the anode to itself and furnishes the cathode with fresh ones too. The hole at the centre of the anode disk allows some electrons to go through and beam onto the far end target.

Theory has stated that heat and temperature of the cathode must reach the specific value of an atomic exit work, for each electron to leave [8]. Several theoretical approaches have been extremely helpful and suggesting that electrons should potentially set to be moving to certain velocities and accelerations to radiate visible light, and so to be seen thereafter [9].

Materials and experiments

Experiments with cathode ray balloons are conducted in our physics labs and students have been able to work with them.

Lab equipment is listed below:

1. Cathode ray balloon
2. Electric sources
3. Transistors (pnp)
4. Ammeters
5. Resistors
6. Connection wires
7. Magnet
8. Computer
9. Interface (Paravia – purchased with the help of Tempus and Joint European Projects)
10. Current probe sensor (Paravia – purchased with the help of Tempus and JEP)

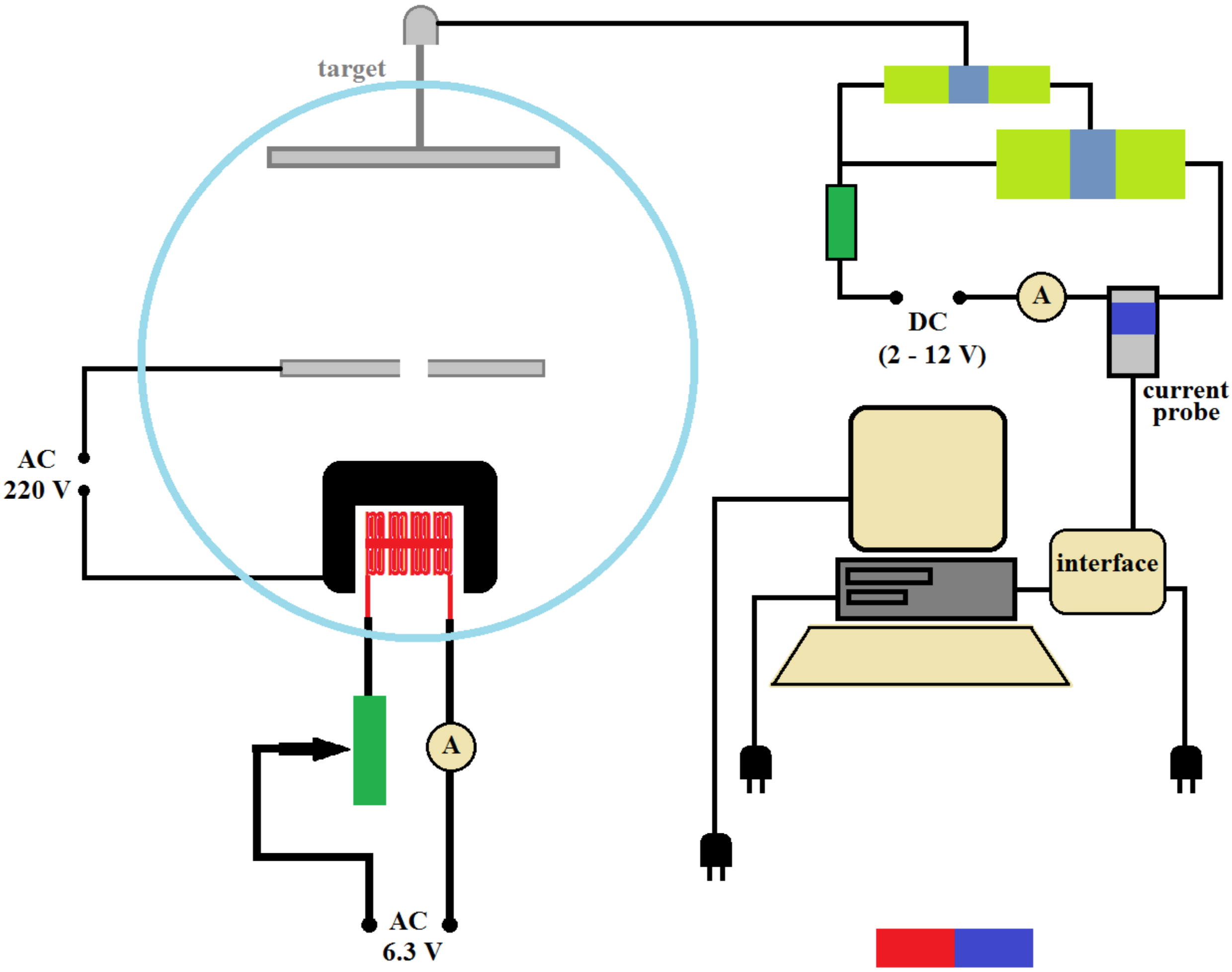

Figure 1

Experiments are built according to the design shown in figure 1. A bridge scale of two transistors is used to amplify signals from target.

Experiment 1

The first experiment is used to study thermionic emission of electrons due to current crossing the heating filament. Hence, an electron beam hits the target, and signals are detected by a specific circuit containing two transistors pnp and the ammeter. As the current of the filament changes, the target current changes too, table 1 and graph 1. Data from table 1 are used to calculate the ratio between currents, i.e. filament heating current versus target detecting current, table 2.

Table 1

If (mA) Ammeter AC	It (mA) Ammeter DC
250	6.5
280	13
290	14.25
300	16.75
310	18.25
320	20.75
325	22.25
330	25
340	21.25
350	23.25
360	22.25

Graph 1

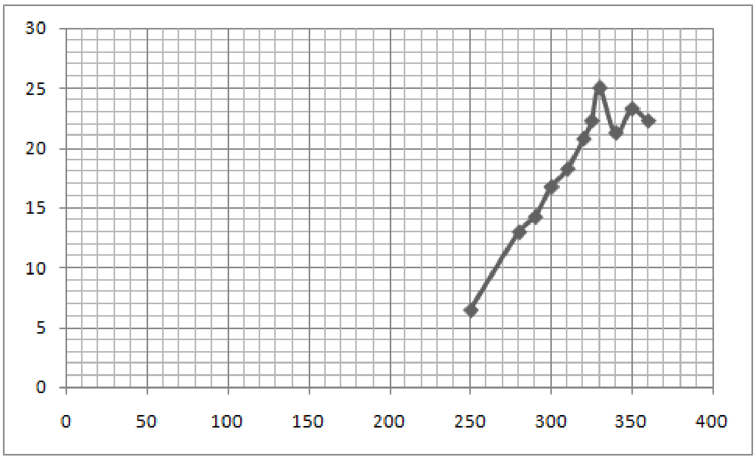

Table 2

If (mA) Ammeter AC	It (mA) Ammeter DC	K = It / If
250	6.5	0.052
280	13	0.092857143
290	14.25	0.098275862
300	16.75	0.111666667
310	18.25	0.117741935
320	20.75	0.1296875
325	22.25	0.136923077
330	25	0.151515152
340	21.25	0.125
350	23.25	0.132857143
360	22.25	0.123611111

Experiment 2

The second experiment is used to detect signals from the electron beam hitting on the target. Signals are detected by a specific circuit containing two transistors pnp, the ammeter, the current probe sensor and interface. Signals, transmitted to the computer, are displayed on screen as graph or digit data, thanks to the Sampler paravia program (purchased with the help of Tempus and JEP), figure 2. As a changing external magnetic field applies on the beam, signals on screen change too.

Figure 2

Conclusions

Working with cathode ray tubes and balloons, students observed and realized some important features and relevant properties of the electron beam and electron.

1. Electron beam is of electric origin; therefore, electron should have electric properties.
2. Electron beam is generated with the help of the heating filament; therefore electron should have thermal properties.
3. Electron beam is visible; therefore electron should have optical properties.
4. Electron beam deviates its straight path and misses target, whenever a magnetic field applies; therefore, electron should have electromagnetic properties. *An external changing magnetic field can be applied by using a*

constant magnet in motion, or a changing current core coil, outside the balloon.

5. Electron beam influences the detecting currents when hitting target; therefore, electron should have electric properties.
6. Electron beam causes millwheel rotation when hitting its wings; therefore, electron should have mechanical properties, such as momentum and else.
7. Electron beam changes shape under an external electrostatic field; therefore, electron should have electrostatic properties. *The external electrostatic field can be applied by using a rubbed and charged ebonite disk and contacting the external head of the target.*

Naturally these are only a few features and properties of the electron that we managed to demonstrate, but they provided a deep understanding to assist physical views of the microworld. Spotted properties of the electron beam enabled us to build analogies and work with similarities, which are both two well known methods in physics [10][11]. For instance, electrons' thermionic emission can be described similar to the macro phenomena of hot water evaporation. Moreover, the physical relationship between the heating current and the target current can be also introduced in terms of a common math accessory in physics:

$$It = f\ (If) \qquad \text{or} \qquad It = K\ If$$

According to graph organizer, observations, measurements and theory are all needed to create a good model to study and explain the qualities and quantities of the electron beam, and, hence, the electron itself [12].

Such activities, not only helped us to satisfy the contemporary demand for precise measurements in physics, but also to establish a fruitful socio – scientific class environment on the topic. To this aim, an entertaining class activity was to invite students to use their own cell phones and shoot some photos of the electron beam, which could be later zoomed, enhanced, or developed for better views [3].

References

[1] Plücker, M. (1858-12-01). "XLVI. Observations on the electrical discharge through rarefied gases". The London, Edinburgh, and Dublin Philosophical Magazine and Journal of Science. 16 (109): 408–418. doi:10.1080/14786445808642591. ISSN 1941-5982

[2] Arabatzis, T. (2006). Representing Electrons: A Biographical Approach to Theoretical Entities. University of Chicago Press. pp. 70–74, 96. ISBN 978-0-226-02421-9. Archived from the original on 2021-01-07. Retrieved 2020-08-25.

[3] Alizoti, A. (2021). Computer – Aided RGB analyses of images. *Technium: Romanian Journal of Applied Sciences and Technology*, *3*(8), 1–12. https://doi.org/10.47577/technium.v3i8.4691

[4] Alizoti, A. (2022). The application of multiple parallel diodes to control large currents. Technium: Romanian Journal of Applied Sciences and Technology, 4(1), 1–6. https://doi.org/10.47577/technium.v4i1.5484

[5] Faraday, Michael (1849). Experimental Researches In Electricity. Vol. 1. London: The University of London.

[6] Avadhanulu, M.N.; P.G. Kshirsagar (1992). A Textbook Of Engineering Physics For B.E., B.Sc. S. Chand. pp. 345–348. ISBN 978-8121908177. Archived from the original on 2 January 2014.

[7] Poole, Ian (2012). "Vacuum tube electrodes". Vacuum Tube Theory Basics Tutorial. Radio-Electronics.com, Adrio Communications. Archived from the original on 4 November 2013. Retrieved 3 October 2013.

[8] Liang S. J. and Ang L. K. (January 2015). "Electron Thermionic Emission from Graphene and a Thermionic Energy Converter". Physical Review Applied. 3 (1): 014002. arXiv:1501.05056. Bibcode:2015PhRvP...3a4002L. doi:10.1103/PhysRevApplied.3.014002. S2CID 55920889.

[9] Keller F. J., Gettys W. E., Skove J. S., Physics Clasical and Modern, pp. 519, 559, 560, 651, 659, 660, 757, 848 – 850, 970 – 1064, McGraw – Hill, USA ISBN 0–07–112674–0

[10] Çorati R., Mulaj Z., Alizoti A. (1994) Application of modelling and analogies in physics teaching, Ege University, Izmir BPU – 2 Turqi, Second General Conference of the Balcan Physical Union, Balcan Physics Letters, Turqi, 12 – 14 Shtator 1994.

[11] C. White, A. Alizoti, (1995) Computer – Aided Visualisation of Similarities in Physics, Open University ALT – C 95 Milton Keynes, Association for Learning Technology, Milton Keynes, UK

[12] A. Alizoti, F. Vila, Z. Mulaj, P. DHoqina (2013) Contemporary Tendencies in Physics Education, (poster) 2nd International Conference, Research and Education in Natural Sciences, November, 2013 15-16, Shkoder - Albania, Procedings, Vol. 1, pp. 637-642, 2013 ISBN987-9928-4135-5-0