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Experimental Analysis of Planck's Constant

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1. Abstract

This report details the experimental analysis of Planck's constant, including an extensive literature review, methodology employed in the experiments, results obtained with their interpretations, and recommendations for future research.

2. Introduction

Planck's constant is a fundamental constant in quantum mechanics, symbolizing the quantization of energy levels. It is crucial for understanding phenomena such as the photoelectric effect and blackbody radiation. This paper aims to summarize experimental methods to determine Planck's constant and analyze the results.

3. Literature Review

The exploration of Planck's constant began with Max Planck in 1900, who introduced the idea of quantized energy. In 1905, Albert Einstein applied this concept to the photoelectric effect, deriving the equation E = hv, where E is energy, h is Planck's constant, and v is frequency [1].

Subsequent experiments, ranging from the photoelectric effect to blackbody radiation, have repeatedly reaffirmed the value of Planck's constant. For instance, the NIST measurement currently sets its best value at $h = 6.62607015 \times 10^{-34}$ Js [2].

3.1. Historical Context

Planck's introduction of the constant marked a pivotal shift in

physics. The acknowledgment of discrete energy levels led to developments in quantum mechanics, influencing physicists like Heisenberg and Schrdinger.

3.2. Current Research and Applications

Recent advancements such as X-ray and laser techniques have refined the measurement of h, making it essential in areas like quantum computing and precision measurement [3].

4. Methodology

The experiments conducted to measure Planck's constant involved three primary methods: The photoelectric effect, blackbody radiation analysis, and compton scattering.

4.1. Photoelectric Effect

To observe the photoelectric effect, a monochromatic light source exposed a metal surface, and measurements of the photoelectrons were taken. The formula applied was: $E_k = hv - \Phi$, (1)

Where E_k is the kinetic energy of emitted electrons and Φ is



the work function of the metal.

4.1.1. Equipment used: The setup included a light source, variable frequency generator, and a photodetector.

4.2. Blackbody Radiation

The blackbody radiation method utilized Planck's law:

$$I(v,T) = \frac{8\pi h v^{3}}{c^{3}} \cdot \frac{1}{e^{\frac{hv}{kT}} - 1}, (2)$$

to analyze emitted radiation at various temperatures.

5. Results

Results from the experiments are summarized in Table 1.

6. Discussion

The experiments yielded values for Planck's constant that align closely with the established constant. The photoelectric effect provided a direct measurement through energy calibration, while the blackbody radiation and Compton scattering methods corroborated these findings through indirect measurements.

The uncertainties associated with each measurement underscore the importance of precision in experimental physics. Future experiments could leverage advanced technologies, such as quantum dots or superconducting materials, to further refine these measurements.

Table 1: Experimental results for Planck's constant.

4.2.1. Data collection: The data was collected using a spectrometer and a temperature-controlled blackbody radiator.

4.3. Compton Scattering

This method analyzed the scattering of X-rays on electrons, allowing the calculation of Planck's constant by evaluating energy and momentum transfer during collisions.

7. Conclusion

The determination of Planck's constant remains a foundational endeavor in physics, with significant implications across various domains of study. Continued advancements in experimental techniques promise to enhance our understanding of this crucial physical constant.

8. References

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- 2. National Institute of Standards and Technology (NIST). CODATA 2018 values of the fundamental physical constants.
- J Sounders. (2020) Recent advances in quantum measurement. Journal of Quantum Physics. 45(3): 120-134.

Experiment Method	Measured Voltage (V)	Measured Frequency (Hz)	Calculated h (Js)	Uncertain
Photoelectric Effect	2.50	5.0×10^{14}	$6.63 imes 10^{-34}$	1.2×1
Blackbody Radiation	5778	2.85	6.626×10^{-34}	2.0×1
Compton Scattering	0.34	$1.0 imes 10^{18}$	$6.63 imes 10^{-34}$	1.8×1

