A Deep Dive into Quantum Mechanics by Bentzi Scharf

IMPp 2024

My Project

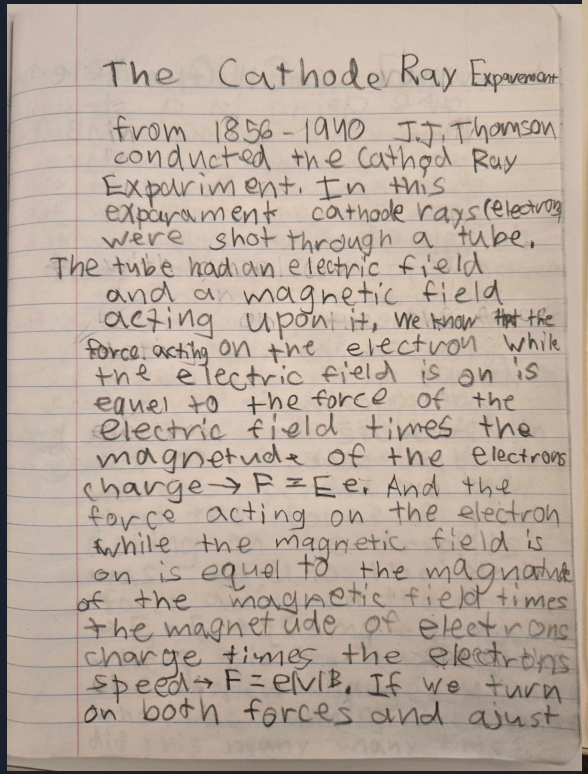
Originally my project was to write research paper about how Quantum Mechanics was developed in the hope that it would help people understand Quantum Mechanics better if they understood where it came from.

My Project

For the first ten or so classes I researched a bunch of the experiments that led up to the development of quantum mechanics and wrote a summary of them in my notebook.

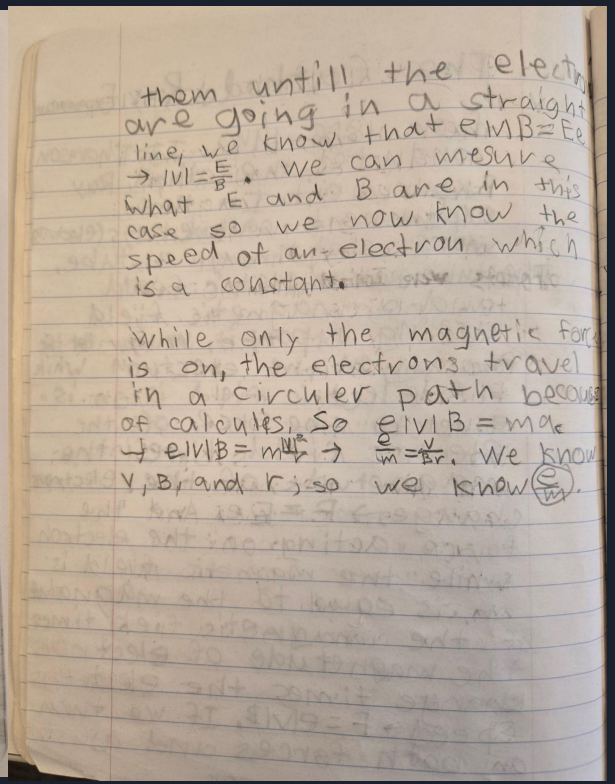
My Project

One of the experiments that I researched was the Cathode Ray experiment that found the charge to mass ratio of an electron



The Cathode Ray Experiment

from 1856-1940 J.J. Thomson conducted the Cathod Ray Experiment. In this experament cathode rays (electrons) were shot through a tube. The tube had an electric field and a magnetic field acting upon it, we know that the force acting on the electron while the electric field is on is equel to the force of the electric field times the magnetude of the electrons charge → $F = Ee$. And the force acting on the electron while the magnetic field is on is equel to the magnatude of the magnetic field times the magnetude of electrons charge times the electrons speed → $F = evB$. If we turn on both forces and ajust

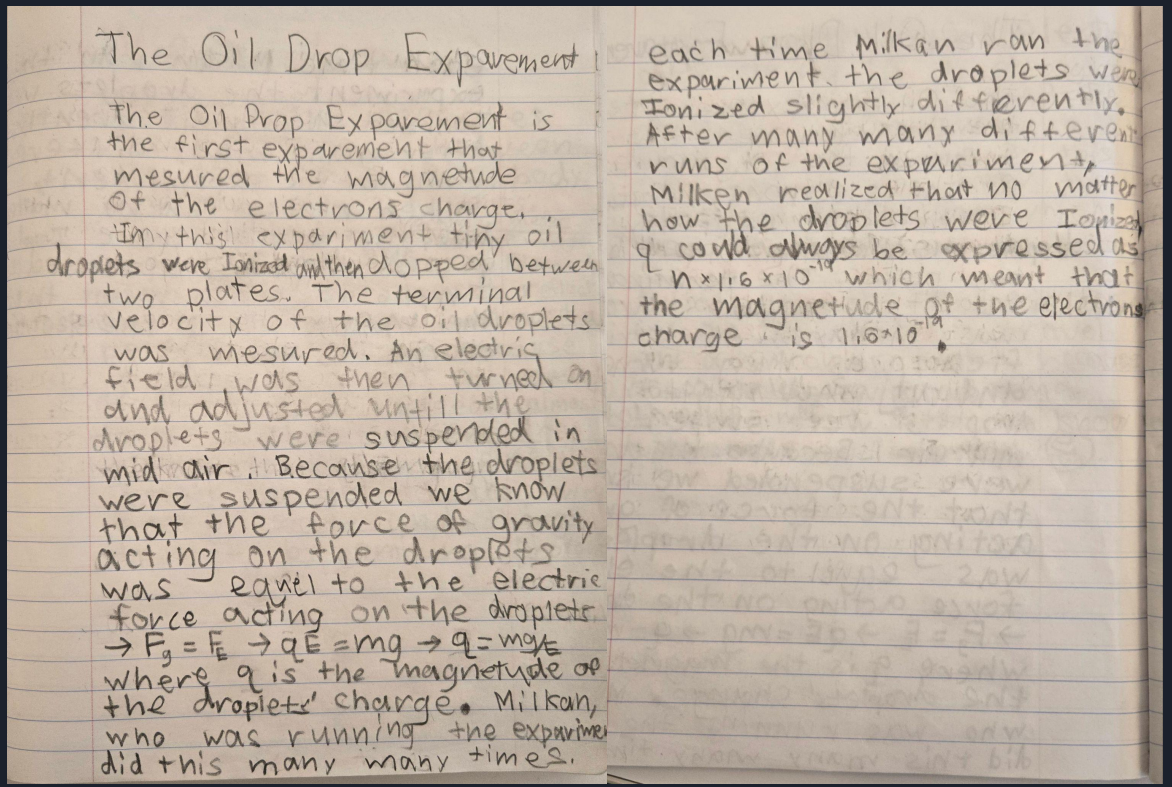


them until the electrons are going in a straight line, we know that $evB = Ee$ → $|v| = \frac{E}{B}$. we can mesure what E and B are in this case so we now know the speed of an electron which is a constant.

while only the magnetic force is on, the electrons travel in a circuler path because of calculus, so $evB = ma_c$ → $evB = m\frac{v^2}{r}$ → $\frac{e}{m} = \frac{v}{Br}$. We know v, B, and r; so we know $\frac{e}{m}$.

My Project

Another one of the experiments that I researched was the Oil Drop experiment that found the magnitude of the charge of the electron



The Oil Drop Exparement

The Oil Drop Exparement is the first exparement that mesured the magnetude of the electrons charge. In this expariment tiny oil droplets were Ionized and then dopped between two plates. The terminal velocity of the oil droplets was mesured. An electric field was then turned on and adjusted untill the droplets were susperded in mid air. Because the droplets were suspended we know that the force of gravity acting on the droplets was equel to the electric force acting on the droplets. $\rightarrow F_g = F_E \rightarrow qE = mg \rightarrow q = mg/E$ where q is the magnetude of the droplets' charge. Milkan, who was running the exparimen did this many many times.

each time Milkan ran the expariment the droplets were Ionized slightly differently. After many many different runs of the expariment, Milken realized that no matter how the droplets were Ionized, q could always be expressed as $n \times 1.6 \times 10^{-19}$ which meant that the magnetude of the electrons charge is 1.6×10^{-19}.

My Project

After the first ten or so classes I realized that I wouldn’t have enough time to write the research paper because I had missed a bunch of classes for a variety of reasons. So I decided to shift my focus to Quantum Chromodynamics, the physics of the strong force, because I was more interested in it.

My Project

For the rest of IMP I researched Quantum Chromodynamics which is the physics of the strong force and quarks. All of my research is in my notebook, but I will be explaining everything I learned from 7:00-7:20

The End