Title:
Stern-Gerlach Experiment Simulation
Researchers:
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Introduction:
In 1922 Otto Stern and Walther Gerlach performed a revolutionary experiment that would confirm the quantization of the electron spin. The experiment was a big accomplishment for quantum mechanics, as it confirmed the quantization of spin angular momentum in the form of ±1/2. This result is purely quantum mechanical, and does not compute with the classical physics. While the result of this experiment is well documented and no longer being contested, we would like to create computer simulations to better understand how the semi-classical result plays out. The original experiment consisted of passing silver atoms, as silver has an unpaired 5s electron, through an inhomogeneous magnetic field. The electron has an electron spin magnetic moment, which wants to align itself with this magnetic field producing a torque. Apart from the torque, there is also a force on a magnetic dipole. Thus, introducing silver atoms into an inhomogeneous magnetic field will produce a split depending on the sign of the spin. For the semi-classical model, the electron spin will be unrestricted between values of ±1. This contradicts the quantum mechanical approach which restricts the spin to a specific set of values. We hope to simulate this effect through wave-packets propagation through a potential created by the magnetic field. This will be achieved by solving the Time Dependent Schrodinger Equation.

Approach:
In the semi-classical approach, we will use kinematics as the magnetic field produces a constant force and thus an acceleration. For the wave packet propagation, we will solve the Time-Dependent Schrodinger Equation. The magnetic field creates a potential step function that is a constant perturbed potential beginning at time t=0 and lasts until some later time t=T. Using a Gaussian wave packet along with the finite difference method, we are able to update the Gaussian wave packets position with respect to time. We will use the python package, matplotlib.pyplot, to plot the wave function probability density as time progresses.

Objectives
Some of the objectives included for the semi-classical portion include creating a more realistic scenario by varying the initial velocities in all directions. The reason that this is important is because the original experiment included an oven that could not produce a perfect beam of Silver atoms. We want our results to change every time we run the script. We want to plot the atoms as scatter plot, where each dot is where an individual atom hit the screen. For the quantum portion, we hope to model the wave packet as a movie. One with a dampening term and one without.

Results
Following the experiment we found our results matched the expected result for the semi-classical model. The screen showed a pattern that was oval in nature and the density of atoms increased toward the edges of the oval. For the Quantum mechanical portion we were able to turn our data into a movie, which demonstrated the split that identifies with he quantized spin splitting.