**Introduction**

The Stern-Gerlach experiment demonstrates that when a beam of silver atoms, which have 46 coupled electrons forming a spherically symmetric configuration and one single electron in the 5s orbital, passes through an inhomogeneous (nonuniform) magnetic field taken to be along the z-direction and with some deviation in the x-direction the beam splits into two discrete states being spin up or spin down. This effect is purely quantum mechanical and it is owing to an inherent property possessed by particles called *Spin* angular momentum. Spin is an intrinsic degree of freedom that is separate from moving particles’ spatial degrees of freedom. In this project we wished to reconstruct the results of the Stern-Gerlach experiment in the classical limit where the states of the electron were assumed to be a continuous distribution band symmetric about the initial axis of motion, z = 0. After this was accomplished we sought out to simulate the correct distribution of states of the electron, spin up or spin down, by using the finite difference method with a Gaussian wavepacket implemented in Python.

**Theory**

The magnetic dipole moment, μ, due to electrons is given by,

where is the spin operator that holds the Pauli spin matrices and is the gyromagnetic ratio. The inhomogeneous magnetic field is given by,

The time-dependent two-dimensional Schrodiner to be solved for the electron in the region of space containing the magnetic field is stated as,

So that the energies and eigenstates are,

Method

To solve the two-dimensional Schrodiner equation numerically the finite difference method was utilized where space and time were discretized onto a lattice and the wavefunction was solved at each site on the lattice. When using the finite difference method, the second-ordered spatial derivatives, the first-ordered spatial derivatives, and the time derivative in Schrodiner equation can be approximated by using the central difference approximation and the forward difference approximation respectively,

Here the errors are second ordered and the z – spatial derivatives are of the same form as the x-spatial derivatives.

Results

**Conclusion**

The results that were obtained in the classical limit showed that when electrons exit the magnetic field they can populate any state that is symmetric about their initial axis of motion between (this was an arbitrary choice states for the randomized states). The quantum result showed an interference distribution that was heavily peaked about the initial axis of motion when the diffusion coefficient (1/mass) was considered which differed from the classical result because it was not a continuous band. When the diffusion coefficient was set to unity the result showed two Guassian distributions splitting about the initial axis of motion which imitated the same initial behavior as the result with diffusion, but noticeable difference was that there was not any interference behavior. What showed was two distributions heavily peaked at what could be considered as two “quantum” states. For future work we are anticipating simulating the experiment by using the Crank-Nicolson method.

**Literature cited**

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