Survey of quantum physics

Stern-Gerlach experiment, electron spin and analogy with polarization of light

Stern-Gerlach, 1932

A beam of iron atoms deflected by a magnetic field gradient. What do we expect from classical physics?

Ag = (0, 0, 0)

What we expect from classical physics

What is actually observed

Sequential Stern-Gerlach experiments

Explanation of S-G: Just like polarization of light!

- Light is a transverse wave, even if it propagates along a single direction.
- Polarized waves: Only move in one plane (left or right)
- Unpolarized waves: Move in all planes

Explanation of S-G: Analog with polarization of light

$x_1$ - atoms $→$ unpolarized light

$x_2$ - atoms $→$ circularly polarized light

- This suggests the following connection:

$b = m$ = spin quantum number

- But something is missing: What about the states created by $S_G$?

- The model predicts an equation with $b$ times $n_b$, and is only true for $b = 0$. What about the green line?

- This is like circularly polarized light.

States $S_G$: Analogous to circularly polarized light!

$|\alpha\rangle$ - spins aligned in one plane

$|\beta\rangle$ - spins aligned in the opposite plane

N = 1.2 $\times$ 10$^{10}$ atoms

- In the real world finished, we will only see the red line emerging from the $S_G$, as expected.

Summary

- Quantum mechanics predicts a new state for protons $|\alpha\rangle$ and electrons, analogous to the Stern-Gerlach experiment.

- Classical physics cannot explain the splitting of the beam.