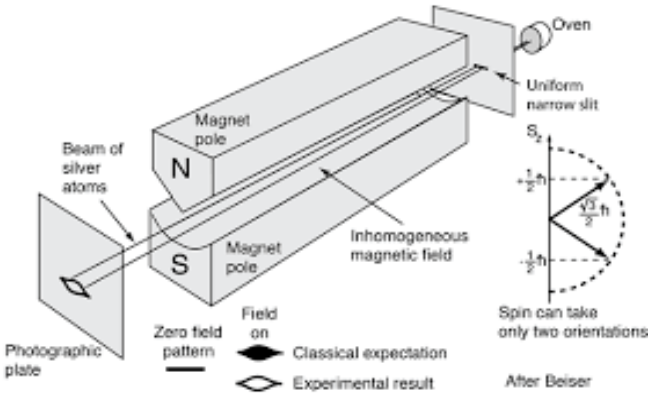
The Stern - Gerlach Experiment

The concept of vector atom model was introduced to explain certain experimental observations in the atomic spectra of complex atoms. This atom model has the two special features : spatial quantization and the electron spin. Direct experimental confirmation of these features was provided by the Stern - Gerlach experiment.

The magnetic moment μ of an atom arises due to orbital and spin motions of the electrons. In a uniform magnetic field, the magnetic moment vector experiences a torque which tends to turn the direction of μ and hence that of angular momentum with magnetic field. This makes the vector μ to process around the field keeping a fixed angle θ with the field. If the magnetic field is nonuniform, the atom with the magnetic moment experiences an additional translatory motion. Hence if an atom with magnetic moment is shot in the x - direction through a magnetic field which increases along the z - axis, it will be deflected in the positive or negative z - direction. The shift will depend on the value of μ_z. if μ_z takes continuous values the beam would spread out into a continuous band in the xz- plane. Instead , if there is space quantization each atom will enter the magnetic field in a particular quantum state defined with the magnetic field direction as the axis. Consequently, the beam will split into separate beams and produce a series of distinct spots or sharp lines, one for each possible value of μ_z .

In their experiment, stern and Gerlach passed a collimated beam of silver atoms through an inhomogeneous magnetic field produced by specially designed electromagnet. While passing through the magnetic filed, the beam splits into two spots on the screen.



In the ground state, the outer electron of silver atom is in as s-state (5s). Therefore, it has no orbital angular momentum and consequently no orbital magnetic moment. The observation of 2 spots suggests that all electron have an intrinsic magnetic moment of the same magnitude with two possible orientations - parallel or antiparallel to the magnetic field. The origin of this magnetic moment can be understood if it is assumed that the electron of the silver atom has an intrinsic spin angular momentum. If the spin of the electron is s, the z-component of spin can have 2s+1 orientations. As two spots have been observed experimentally 2s+1 = 2 or S = 1/2. That is, the spin of the electron is 1/2. Thus, spin, first detected in the Stern - Gerlach experiment, has become an ‘observable’.