Lecture Notes of B.Sc.(HONS.) PHYSICS ,Part-II, Paper -IV

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TOPIC:-------Stern and Gerlach Experiment

AIM: The aim of this experiment is to define

(i) Concept of space quantization
(ii) Spinning motion of electron

Experimental setup: Consider a beam of Ag (silver) atom which was passed through an inhomogenous magnetic field .To produce the beam , Ag (silver) was vaporised by heating it in a small electric oven ,which was furnished with a slit shaped exit aperture. Two further slits also exist. Then a thin beam of Ag which travel along X axis passed between the magnet pole pieces N and S. To avoid deflection of silver atoms the arrangement was enclosed in a highly evacuated glass vessel. The magnetic field between specially pole pieces had a large space rate of vibration provided by having one pole in the form of a knife edge and other in the form of channel. The magnetic field has much intensity near the knife edge than anywhere in the gap. The beam strikes on glass plate P after emerging from the field. Two cases exist:

- In homogenous magnetic field the lines are equidistance from each other so there is no transverse displacement.
- In non-homogenous magnetic field transverse displacement is in +Z direction .When field off a thin straight line was obtained on P. When

field is on the trace was divided into two lines except at the ends where Ag passes through the field outside the region of strongest field near the knife edge shaped pole piece. This result confirm the existence of electron spin and the postulates of Space Quantisation.

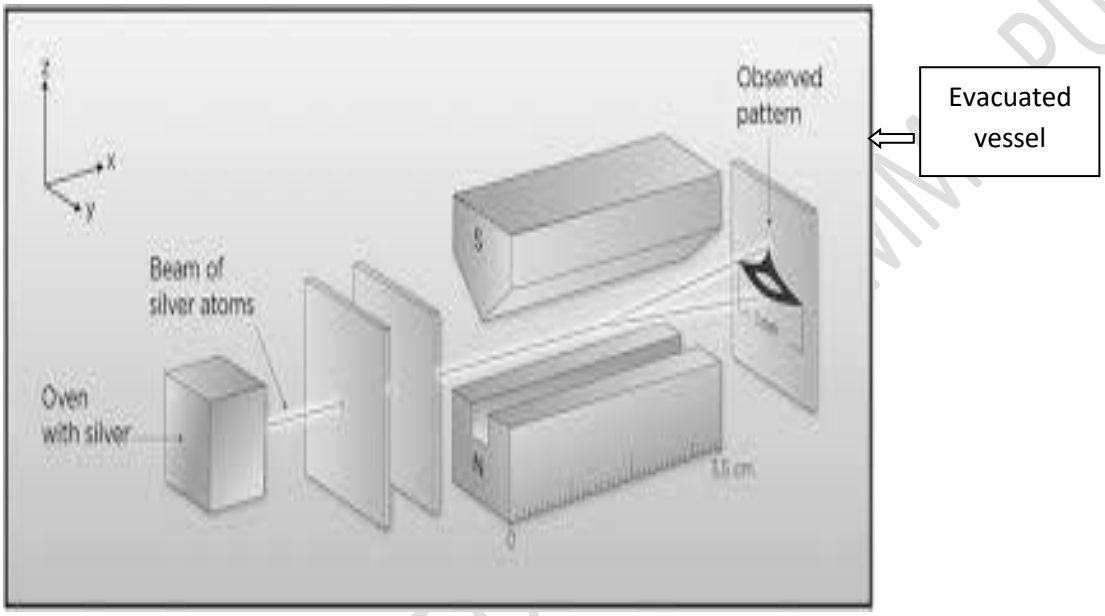

Fig. Experimental Setup for Stern and Gerlach Exp.

Atomic no. of Ag, Z= 47

Electronic congfiguration:$1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 3d^{10}\ 4s^2\ 4p^6\ 4d^{10}\ 5s^1 \equiv {}^2S_{1/2}$ state

{in general ${}^{2j+1}L_j$ where j=l+s=0+s=1/2}

$m_{j=}$-j to +j= (2j+1) values

$\cos \omega = m_j / j = -1$ or $1 \Rightarrow \omega = 0^0$ or 180^0

This shows that magnetic moment will be directed along field direction or opposite to it.

Conclusion from Stern and Gerlach Experiment:

- There exist a directional quantization. There are only discrete possibility for the orientation relative to a magnetic field ,in this case two ,parallel and antiparallel.
- This method provided observed values for atomic magnetic moments ,if the magnitude of the field gradient is known.
- The s electron has a orbital angular momentum l=0 and one observes only spin magnetism.
- All atoms which have an s electron in the outermost position ,the angular momenta and magnetic moments of all inner electrons cancel each other, which gives the same value for the deflection force .One measures only the effect if outermost electrons.
- Like gyroscopes ,atoms maintains the magnitude and direction of their angular momenta during their motion in space.