The Lorentz Force

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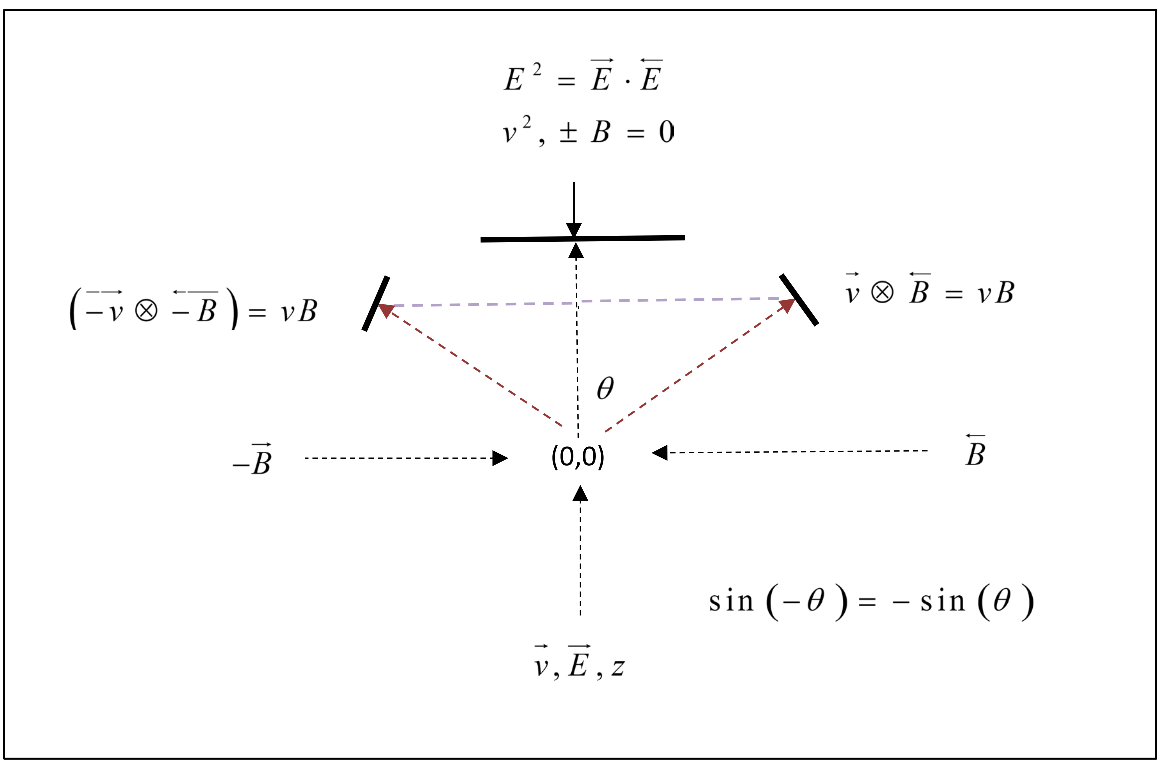
Fermions (my PDF)

The Lorentz Force

The Lorentz force is defined by the relation: $\vec{F} = q\left(\vec{E} + \vec{v} \otimes \overleftarrow{B}\right)$, noting that E is first order (as a coordinate or momentum) but if v and B are first order, then $\vec{v} \otimes \overleftarrow{B}$ is second order, and must be interpreted as area or energy (mass).

Then $f_m = mA = mP_{x=0} = f_q = q\left(\vec{E} + \vec{v} \otimes \overleftarrow{B}\right)_{x=0}$ so that $\left(\frac{m}{q}\right)P_{x=0} = \left(\vec{E} + \vec{v} \otimes \overleftarrow{B}\right)_{x=0}$ where $\left(\frac{m}{q}\right)$ represents the mass-to-charge ratio.



$\vec{E}$ represents the momentum of a stream of un-ionized atoms (moving bosons, or the atmosphere, which doesn't move, and surrounds the experiment), and does not interact with ionized silver atoms, initially moving toward $(0,0)$ at unit "momentum" v. If there is no B field, both streams impact the target at the top of the page.

When the B field is turned on, the ionized atoms are diverted to each side by the contact existence of the B field at $(0,0)$. Note that vB is second order (Energy, Mass).

Note that if E interacts with vB where the existence of both terms is given by $\# := E + vB$ then $\#^2 = E^2 + vB^2 + E(2vB)$ in contrast to the term $\vec{v} \otimes \overleftarrow{B}$ in the Lorentz force, which means that the only half the value appears – that is, the Lorentz force only expresses the "right hand" rule, whereas the complete expansion is $2vB = v \otimes B + [-(v \otimes -B)] = 2vB$.

The Lorentz force is therefore related to Fermions in the context of the Stern-Gerlach experiment, with the "Spin" S defined as $S = \frac{h}{\sqrt{2}} = \frac{\sqrt{E(vB)}}{\sqrt{2}}$ where $h^2 := 2E(vB) = 2S^2$

Consider the experimental apparatus where the z-axis represents the initial path of both ionized and un-ionized silver atoms, with a contact along the path at which a B field can be applied.

Since $\vec{E}$ does not interact with $\vec{v} \otimes \overleftarrow{B}$ in this configuration then $\left(\vec{E} + \vec{v} \otimes \overleftarrow{B}\right)_{x=0}$ is represented by the matrix

$\begin{vmatrix} E & 0 \\ 0 & vB \end{vmatrix}$ where $Tr \begin{vmatrix} E & 0 \\ 0 & vB \end{vmatrix} = E + vB,\ Det \begin{vmatrix} E & 0 \\ 0 & vB \end{vmatrix} = E(vB)$ in first order.