Notes
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Alternate Way to Handle Electrodynamics

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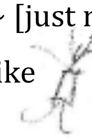
First from charge conservation (arguments of ~~Franklin~~ Faraday)

and relativity (including conservation of energy & momentum)

get to $\boldsymbol{F} = q(E + \boldsymbol{v} \times \boldsymbol{B})$ with $\boldsymbol{A}, \phi$ ~ or at least $\nabla \cdot \boldsymbol{B} = 0$, $\nabla \times \boldsymbol{E} = -\frac{\partial \boldsymbol{B}}{\partial t}$

Second
- Discuss field idea as quantity at a point,
- Differential Operators
- Motion of electrons in given fields

Faraday induction etc.

In each case trying to leave the exact way fields are produced by charges to later ~ [just rough ideas now: eg: Magnet makes magnetic field like  etc (from high school)

Third Get the other two field equations

HOW!? By relativity ~~thru~~ to $\Box^2 \boldsymbol{A} = \boldsymbol{j}$? or other principle?

Or By experimental discussion of Coulomb law, Ampere Law etc.

↑ Surely include

Fourth Discuss the field produced in various circumstances – semistatic

Condensers, Inductances , etc.

Fifth Discuss the field in wave situations – radiation, waveguides etc

Sixth Energy in field. Problems. Self Mass Liénard Wiechert Etc

Seventh Matter. $\mathbb{D}, \mathbb{H}$ etc

Disadvantages – 1. Experimental Historical Basis Completely Lost

[But this is necessary on any new method of presentation]

2. Abstract at beginning. [This must be studied very carefully and the most simple and realistic (non-abstract) attack on item "First" must be made].

In fact the value of the whole scheme depends on how you do "First" and "Third."

Possible Advantages – Closer at beginning to modern idea of field – may even be able to describe scalar field – finite mass field, etc. from beginning – so E&M is, ab initio just one of several fields, which we study first.

Lose that feeling of creeping forward at beginning.

Lect 2

Prove $\boldsymbol{F}$ of form $\boldsymbol{E}+\boldsymbol{v}\times\boldsymbol{B}$.

(1) if $\boldsymbol{F}$ is force on a charge moving anyhow

$\boldsymbol{F}(\boldsymbol{v},x)$ has (by cons. of charge) the mean value $\boldsymbol{F}(\boldsymbol{0},x)$ for a charge at rest if the mean $\boldsymbol{v}=\boldsymbol{0}$ (because oscillations in atom ~~get~~ feels same force as fixed nucleus)

$\therefore \boldsymbol{F}$ is linear in $\boldsymbol{v}$. $F_x = E_x + v_x B_{xx} + v_y B_{xy} + v_z B_{xz}$ etc.

(2) Next Since $F_t = \boldsymbol{v}\cdot\boldsymbol{F}$, $F_t = \boldsymbol{v}\cdot\boldsymbol{E} + v_x v_x B_{xx}$ etc.

But under relativity F_x, F_t mix up & can't get bilinear to mix linear as new F'_x must still be linear [or see other side]

so $B_{ij} = -B_{ji}$ $\quad \vec{F} = \vec{E} + \vec{v}\times\vec{B}$ $\quad$ and $\vec{F} = \vec{v}\cdot\vec{E}$

(3) Law of transformation of fields (from transformation of $\boldsymbol{F}$) [see other side]

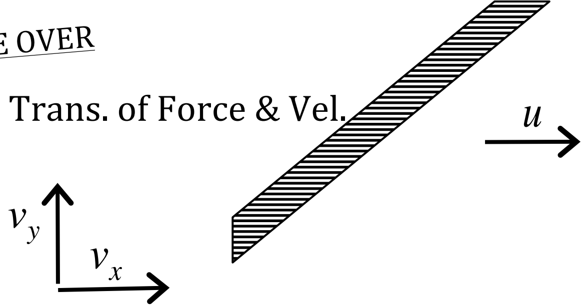
$F'_x = \sqrt{1-u^2}\,E_x \qquad B'_{xy} = B_{xy} - uE_y$ ← so moving charges make magnet, etc

Can you find other ways – Can you get potentials in ?

Is there anything wrong with a theory that law is coulomb transformed instantaneous?

SEE OVER

Trans. of Force & Vel.



$$1 + uv'_x = \frac{1-u^2}{1-uv_x}$$

$$v'_x = \frac{v_x - u}{1 - \frac{uv_x}{c^2}}$$

$$v'_y = \frac{v_y}{1-uv_x}\sqrt{1-u^2}$$

$$\sqrt{1-v'^2} = \sqrt{1-v^2}\sqrt{1-u^2} \Big/ 1 - uv_x$$

$$\frac{F_x}{\sqrt{1-v^2}}, \quad \frac{F_y}{\sqrt{1-v^2}}, \quad \frac{F_t}{\sqrt{1-v^2}}$$

four 4 vector

$$\frac{E_x + v_x B_{xx} + v_y B_{xy} + v_z B_{xz}}{\sqrt{1-v^2}}, \quad \frac{E_y + v_y B_{yy} + v_x B_{yx} + v_t B}{\sqrt{}},$$

$$\frac{E_x v_x + E_y v_y + E_z v_z + v_x v_x B_{xx} \text{ etc } + v_y v_z B_{yz}}{\sqrt{}}$$

$= 4$ vector.

$$F'_x = \frac{\sqrt{1-(v')^2}}{\sqrt{1-v^2}}(F_x - uF_t) = \frac{\sqrt{1-u^2}}{1-uv_x}(F_x - uF_t)$$

$$= \frac{\sqrt{1-u^2}}{1-uv_x}\left[\begin{array}{r} E_x - uv_x E_x - uv_y E_y - uv_z E_z + v_x B_{xx} - uv_x v_x B_{xx} \\ + v_y B_{xy} - uv_x v_y B_{xy} - uv_x v_z B_{xz} \\ - uv_y v_x B_{yx} \end{array}\right]$$

$$= \sqrt{1-u^2}\ E_x - uv'_y E_y - uv'_z E_z + \frac{v'_x + w}{1+wv'_x}\sqrt{1-u^2}B_{xx} + v'_y B_{xy} - uv'_y \frac{v'_x + w}{1+wv'_x}\left(B_{xy} + B_{yx}\right)$$

$$- \frac{uv'_y v'_z}{1+wv'_x}\sqrt{1-u^2}\left(B_{yz} + B_{zy}\right)$$

etc

$$= E'_x + v'_x B'_{xx} + v'_y B'_{xy} + v'_z B'_{xz}$$

$\therefore B$ is antisym.

$E'_x = \sqrt{1-u^2}\ E_x$	$B'_{xy} = B_{xy} - uE_y$

Lect. 1. On the Conservation of Charge and Mass – Energy (gravity)

That moton does not alter charge – contrast: it does alter Mass (Weight)

Atoms with internal motions still neutral etc. yet weighs more.

Packing fraction. excited atom has higher weight – ∴ Gravity

red shift – experimental proof.

Current in wire still neutral – altho (demonstration) there is force

with other also wire carrying current. (Hint that force depends not only on location but also speed)

Lect. 2

Method 1

Force on charge depends on position & Vel $\boldsymbol{F}(\boldsymbol{v},x)$. Cons. of ch. says

if velocity oscillates with zero mean, mean force = $\boldsymbol{F}(\boldsymbol{0},x)$

or $\overline{\boldsymbol{F}(\boldsymbol{v},x)} = \boldsymbol{F}(\boldsymbol{0},x)$ if $\bar{\boldsymbol{v}} = \boldsymbol{0}$ for any distrib of $\boldsymbol{v}$ $\therefore F_i(\boldsymbol{v},x) = E_i + v_i B_{ij}$ (it must be linear)

Rel says $F_t = v_i \cdot F_i = v_i E_i + v_i v_j B_{ij}$. But rel says in new coord system new $\boldsymbol{F}$ is

mix of F & F_t, but cannot be linear unless B_{ij} is antisym. ↵ Rewrite outline