Electromagnetics, Systems Theory, Fluid Dynamics, and some Fundamentals in Physics

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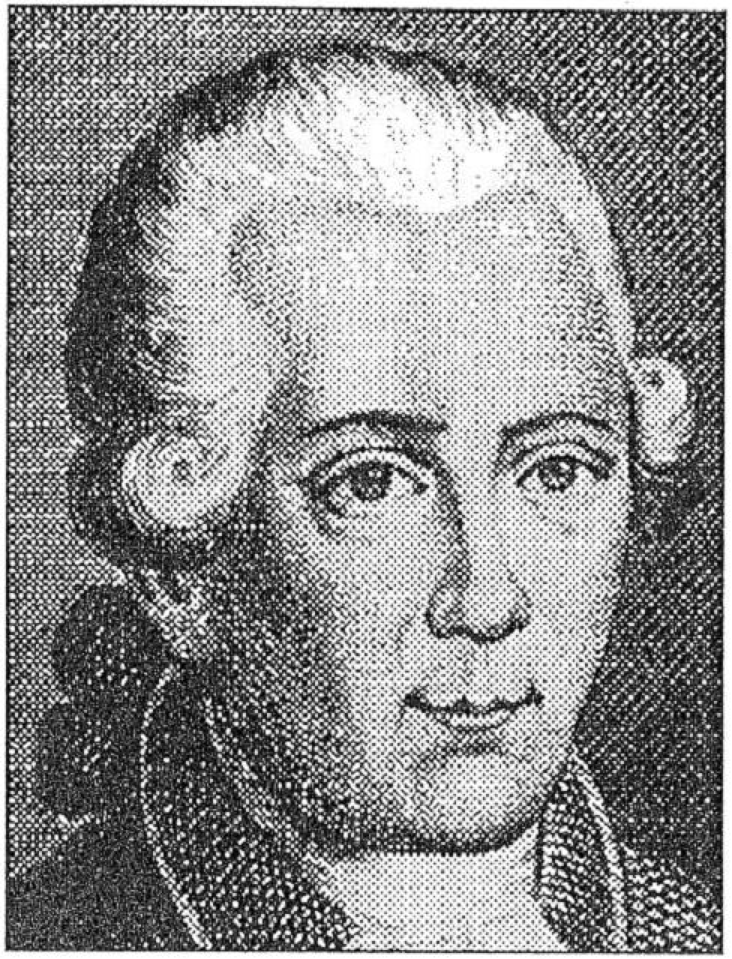
Wörtlich

Was jedermann für ausgemacht hält, verdient am meisten untersucht zu werden.

Georg Ch. Lichtenberg
Physiker und Schriftsteller



"What everybody takes as assured, deserves most to be investigated."

Georg Ch. Lichtenberg, physicist and writer, 1742-1799

Overview

1. The concept of **field velocity** of an electromagnetic (EM) field.
   Rest field, **rest charge** density, **rest current** density.
2. Some **properties** of the field **velocity** and the **rest field**.
3. **Mechanistic** properties of EM field.
4. **Autonomous** (self-sustaining), especially **basal EM fields**.
5. **EM fluid** and **relativistic** interpretation.
6. **Rotating** EM field: model for **electron**, positron.
7. Electromagnetic model of **photon**.
8. Movement of EM particles in external fields
9. Aspects of **generalizing Maxwell's** equations
10. Aspects of **wave mechanics**.
11. Concluding remarks.

Maxwell's equations of **electromagnetic** (EM) **field**,

assuming and constant (here always: **vacuum**, thus $\varepsilon = \varepsilon_o$, $\mu = \mu_o$),

$$\frac{}{t}\mathbf{E} + \mathbf{i} = \quad \mathbf{H}\,, \qquad {}^{T}\mathbf{E} = q, \qquad = (\frac{}{x}, \frac{}{y}, \frac{}{z})^{T}$$

$$\frac{}{t}\mathbf{H} = - \quad \mathbf{E}\,, \qquad {}^{T}\mathbf{H} = 0, \qquad c^2 = 1/$$

From there, as known,

$$\frac{}{t}\mathbf{j} + ({}^{T}\mathbf{T}_c)^{T} + \mathbf{f}_c = \mathbf{0}$$ (valid for Cartesian coordinates),

$$\frac{}{t}w + {}^{T}\mathbf{S} + \mathbf{i}^{T}\mathbf{E} = 0$$

where $w = \frac{1}{2}(\ E^2 + \ H^2)$ = classical **field-energy** density,

$\mathbf{S} = \mathbf{E} \quad \mathbf{H}$ = **Poynting** vector, $E^2 = \mathbf{E}^{T}\mathbf{E}$, $H^2 = \mathbf{H}^{T}\mathbf{H}$,

$\mathbf{j} = \frac{1}{c^2}\mathbf{S}$ = classical **momentum density** of EM field,

$\mathbf{T}_c = w\mathbf{1} - (\ \mathbf{E}\mathbf{E}^{T} + \ \mathbf{H}\mathbf{H}^{T}) = (-)$ **Maxwell stress tensor** (matrix),

$\mathbf{f}_c = q\mathbf{E} + \ \mathbf{i} \quad \mathbf{H}$ = classical **Lorentz- force** density.

Note: **small letters i** , **j**, **f**, q, w etc. used for **densities**. **1**= unit matrix.

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Original set of equations

$$\varepsilon \tfrac{\partial}{\partial t}\mathbf{E} + \mathbf{i} = \nabla \times \mathbf{H}, \quad \varepsilon \nabla^{\mathrm{T}}\mathbf{E} = q$$

$$\mu \tfrac{\partial}{\partial t}\mathbf{H} = -\nabla \times \mathbf{E}, \qquad \nabla^{\mathrm{T}}\mathbf{H} = 0$$

is **equivalent to** set of equations (7 individual ones)

$$\varepsilon \frac{\partial \mathbf{E}}{\partial t} = -\mathbf{i} + \nabla \times \mathbf{H}$$

$$\mu \frac{\partial \mathbf{H}}{\partial t} = -\nabla \times \mathbf{E}$$

$$\frac{\partial q}{\partial t} = -\nabla^{\mathrm{T}}\mathbf{i}$$

combined **with** the **initial conditions** (at $t = t_0$)

$$\varepsilon \nabla^{\mathrm{T}}\mathbf{E} = q \quad \text{and} \quad \nabla^{\mathrm{T}}\mathbf{H} = 0 \quad \text{for} \quad t = t_0$$

Summary of previous results and **observations**:

From **Maxwell's** equations

$$\begin{cases} \frac{}{t}\,\mathbf{j} + (\quad {}^{T}\mathbf{T}_{c})^{T} + \mathbf{f}_{c} = \mathbf{0} & (1), \qquad \mathbf{j} = \frac{1}{c^{2}}\mathbf{S} \\ \frac{}{t}\,w + \quad {}^{T}\mathbf{S} + \mathbf{i}^{T}\mathbf{E} = 0 & (2) \end{cases}$$

Related equations in **fluid dynamics**

$$\begin{cases} \frac{}{t}\,\mathbf{j} + (\quad {}^{T}(\mathbf{v}\,\mathbf{j}^{T}))^{T} + (\quad {}^{T}\mathbf{T})^{T} + \mathbf{f}_{g} = \mathbf{0}, & \mathbf{j} = m\mathbf{v} \\ \frac{}{t}\,w + \quad {}^{T}(w\,\mathbf{v}) + \quad {}^{T}(\mathbf{T}\,\mathbf{v}) + \mathbf{v}^{T}\mathbf{f}_{g} = 0 & \end{cases}$$

1. Proper mechanistic interpretation of (1) +(2) impossible since in (1), **no** term concerning **flow** (convection) of **momentum**, in (2), **no** term concerning **work** done by **stress tensor**.
2. Need a **field velocity v locally** associated with **j**.
3. Viewpoint adopted in this presentation: q and **i** are **properties** of **field**, **not sources**.
4. Later more specifically: field is **autonomous**, **basal**.

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Mathematical definition of field velocity, rest field, etc.:

At arbitrary location P (world point, i.e., position and time)

define: $\frac{2\mathbf{v}}{1 + \ \ ^2} = \frac{\mathbf{S}}{w}$, $\mathbf{v}$ = **field velocity**, thus $\mathbf{v}\ \ \mathbf{S}$,

$\mathbf{E}_o = \frac{1}{\ }(\mathbf{E} + \ \ \mathbf{v}\ \ \ \mathbf{H}) = \_\ E_o$ = **rest electric field**

$\mathbf{H}_o = \frac{1}{\ }(\mathbf{H} - \ \ \mathbf{v}\ \ \ \mathbf{E}) = \_\ H_o$ = **rest magnetic field**

$\mathbf{S}_o = \mathbf{E}_o\ \ \mathbf{H}_o = \mathbf{0}$

$\mathbf{T}_o = w_o\mathbf{U}$, $\mathbf{U} = \mathbf{1} - 2\_\_^T$, $w_o = \frac{1}{2}(\ E_o^2 + \ H_o^2)$, $\_$ = unit **vector**

$E_o^2 = \mathbf{E}_o^T\mathbf{E}_o$, $H_o^2 = \mathbf{H}_o^T\mathbf{H}_o$, w_o = **rest energy density**

$q_o = \frac{1}{\ }(q - \frac{1}{c^2}\mathbf{v}^T\mathbf{i})$ = **rest charge density**

$\mathbf{i}_o = \mathbf{i} - \frac{q + q_o}{1 +}\mathbf{v}$ = **rest current density**

where $\ \ = v/c$, $v^2 = \mathbf{v}^T\mathbf{v}$, $\ \ = \sqrt{1 - \ \ ^2}$, $\_^T\_ = 1$

$\mathbf{S} = \mathbf{E}\ \ \mathbf{H}$, $w = \frac{1}{2}(\ E^2 + \ H^2)$, $E^2 = \mathbf{E}^T\mathbf{E}$, $H^2 = \mathbf{H}^T\mathbf{H}$.

Have: $w_o = 0$ $\ \ v = \ \ c$; E_o^2 , H_o^2 , w_o , $\mathbf{T}_o^T\mathbf{T}_o$: **Lorentz invariant.**

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Summary of **mechanistic interpretation**:

Have $\frac{}{t}\mathbf{j} + (\;^T(\mathbf{v}\mathbf{j}^T))^T + (\;^T\mathbf{T}_o)^T + \mathbf{f}_c = \mathbf{0}$,

$\frac{}{t} w + \;^T(w\,\mathbf{v}) + \;^T(\mathbf{T}_o\,\mathbf{v}) + \mathbf{i}^T\mathbf{E} = 0$,

with $\mathbf{j} = \frac{1}{c^2}\mathbf{S} = m_i\mathbf{v}$, $m_i = \frac{m_o}{\;2}$, $\; = \sqrt{1-\;^2}$, $\; = \frac{v}{c}$

$w_o = \frac{1}{2}(\;E_o^2 + \;H_o^2) = \frac{1}{2}m_o c^2$, $m_o = m_i \;\; \mathbf{v=0}$

$w = \frac{1}{2}(\;E^2 + \;H^2) = w_i + w_{ke} = w_o \frac{1+\;^2}{\;2}$

$w_k = w - w_o = \frac{2\;\;^2}{\;2} w_o$ = **kinetic energy** density

$W = \;_V wdV$ = **total energy** of EM field, etc.

Consistent mechanistic interpretation possible only if adopt for relativistic dynamics not classical, but alternative theory.

Contradicts known experiments?

Crucial question: **How** can this **conflict** be **resolved**?

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Henceforth, always **assume** EM field **basal**: $\mathbf{i}_o = \mathbf{0}$.

The (**nonlinear**!) **flow equations** etc. then simplify to

(1) $\frac{\ }{t}\,\mathbf{j} + (\ ^T(\mathbf{v}\,\mathbf{j}^T))^T + (\ ^T\mathbf{T}_o\,)^T + \mathbf{f}_o = \mathbf{0}$

(2) $\frac{\ }{t}\,w + \ ^T(w\,\mathbf{v}) + \ ^T(\mathbf{T}_o\,\mathbf{v}) = 0$

(3) $\frac{\ }{t}\,q + \ ^T(q\,\mathbf{v}) = 0$

where $\mathbf{j} = m_i = \frac{m_o}{\ ^2}\ ,\quad m_o = \frac{\ ^2}{c^2}\,w_o\ ,\quad w = w_o\,\frac{1 + \ ^2}{\ ^2}$

$\mathbf{T}_o = w_o\,\mathbf{U},\ \mathbf{U} = \mathbf{1} - 2\,\underline{\ }\,\underline{\ }^T,\quad \underline{\ }^T\,\underline{\ } = 1\ ,\quad \underline{\gamma}^T\,\mathbf{v} = 0$

$\mathbf{f}_o = q_o\,\mathbf{E}_o\ ,\quad \mathbf{E}_o = \underline{\ }\,E_o,\quad w_o = \frac{1}{2}(\ E_o^2 + \ H_o^2)$

Comments: 1. All convective flows occur with **v** .

2. In (1), forces depend only on **rest field**.

3. Eq. (2) : only surface forces, not $\mathbf{f}_o$.   4. Have 7 unknowns.

Recall energy equation for **basal** EM field:

$$\frac{}{t} w + {}^{T}(w\,\mathbf{v}) + {}^{T}(\mathbf{T}_o \mathbf{v}) = 0 \qquad (1)$$

Hence, w changes due to **two** entirely different **causes**:

1. Convective **flow** with velocity $\mathbf{v}$: term ${}^{T}(w\,\mathbf{v})$

2. **Work** done by surface forces: term ${}^{T}(\mathbf{T}_o\,\mathbf{v})$

But can **combine** these two phenomena **into single** one.

Have indeed $\mathbf{T}_o\,\mathbf{v} = w_o\,\mathbf{v}$, thus

$$w\,\mathbf{v} + \mathbf{T}_o\,\mathbf{v} = (w+w_o)\mathbf{v} = \frac{2\mathbf{v}}{1+\ ^2}\, w$$

Find: $\frac{2\mathbf{v}}{1+\ ^2}$ = **effective energy velocity** $= c\,\frac{2\_}{1+\ ^2}$

$= \frac{\mathbf{S}}{w} = \mathbf{v}_c = c\underline{\beta}_c =$ **classical energy velocity** , $\mathbf{v} = c\underline{\beta}$

(1) yields: $\frac{}{t} w + {}^{T}(w\,\mathbf{v}_c) = 0$ (**basal** field!),

which describes pure flow of energy with velocity $\mathbf{v}_c$.

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Recall: $\mathbf{v}_c = \frac{2\mathbf{v}}{1+\ {}^2}$ = effective energy velocity

= classical energy velocity,

Then: $\ {}_c = \overline{1 - \ {}^2_c} = \frac{\ {}^2}{1+\ {}^2}$, $\ {}^2_c = \frac{T}{\_c}\ \_c$, $\mathbf{v}_c = c\ \_c$

$\mathbf{j} = \frac{1}{c^2}\ \mathbf{S} = m_i\mathbf{v} = m_c\mathbf{v}_c = \frac{m_{co}}{c}\ \mathbf{v}_c$, $m_c = \frac{m_{co}}{c}$

$w = \frac{w_o}{c}$, $w_o = \frac{1}{2} m_o c^2 = m_{co} c^2$, $m_o = 2m_{co}$

$w_o = w\ {}_{\mathbf{v} = \mathbf{v}_c = \mathbf{0}}$, $m_{co} = m_c\ {}_{\mathbf{v} = \mathbf{v}_c = \mathbf{0}}$

Hence: Use of $\mathbf{v}_c$ yields expressions better **reminiscent** of **classical relativistic dynamics**, with **j** and w assuming strictly the same values as before.

However: Cannot build consistent fluid-dynamic analogy since flow of **j** and q occurs with **v** , **not** $\mathbf{v}_c$.

Solution: 2 **levels** of observation, **primary** and **secondary**.

1. **Primary** or **basic level** of observation of **basal** EM field:

$$\frac{}{t}\,\mathbf{j} + (\ {}^{T}(\mathbf{v}\mathbf{j}^{T}))^{T} + (\ {}^{T}\mathbf{T}_{o})^{T} + \mathbf{f}_{o} = \mathbf{0}, \quad \mathbf{j} = m_{i}\mathbf{v}, \quad m_{i} = \frac{m_{o}}{2}$$

$$\frac{}{t}\,w + {}^{T}(w\,\mathbf{v}) + {}^{T}(\mathbf{T}_{o}\,\mathbf{v}) = 0\,, \quad \frac{}{t}\,q + {}^{T}(q\,\mathbf{v}) = 0, \quad \mathbf{i} = q\mathbf{v}$$

Observed at this basic level, the field behaves like an **EM fluid** with flow velocity **v**.

Analogy based on **alternative** relativistic dynamics.

2. **Secondary level** of observation of **basal** EM field:

$$\frac{}{t}\,w + {}^{T}(w\,\mathbf{v}_{c}) = 0, \quad w = m_{c}c^{2}\,, \quad \mathbf{j} = m_{c}\mathbf{v}_{c}\,, \quad m_{c} = \frac{m_{co}}{c} = \frac{m_{o}}{2\ c}$$

Observed at this secondary level, changes of energy appear to be combined into a single overall flow with **effective velocity** = classical energy velocity $\mathbf{v}_c$.

Analogy based on **classical** relativistic dynamics.

Above results suggest for **EM particles** (electrons, photons...):

EM particles have **inner structure** consisting of **condensed** EM **field** that is strictly governed by **Maxwell's** equations and is basal in an appropriate reference frame RF.

Three levels of **observation**:

1. At **basic** level, EM field appears as **EM fluid**, i.e., involves equations analogous to **fluid dynamics**. Analogy based on **alternative relativistic dynamics**.
2. At **secondary** level: Changes of w combined into overall **energy migration** with effective velocity = $\mathbf{v}_C$, expressions for **j** and w as for **classical relativistic dynamics**.
3. Movement **particle as a whole**: energy flow is relevant. Hence, for such movement and interactions: as for item 2.

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Dynamic flow equations suggest to examine an electromagnetic (EM) **field** that is **basal**, circularly symmetric about an **axis**, and is **rotating** steadily around that axis.

Use **spherical coordinates** r, , :

$x = r \sin \quad \cos \quad, \quad y = r \sin \quad \sin \quad, \quad z = r \cos \quad,$

$dV = r^2 \sin \quad dr\, d \quad d \quad,$ vector $\mathbf{a} = (a_r, a \ , a \ )^T$ etc.

To be precise, assume

1. $\mathbf{v} = (0, 0, v\ )^T$, $\mathbf{i} = (0, 0, i\ )^T$, $\mathbf{i}_o = \mathbf{0}$.

2. Field symmetrical about equatorial plane.

Then: $S_r = S \ = j_r = j \ = E \ = H \ = E_o \ = H_o \ = \quad = \_^T \mathbf{i} = 0$

For field thus specified can determine

$Q = {}_V q\, dV = 2 \quad {}_o r\, dr \ {}_o q \sin \quad d \quad$ = **total charge**,

$L = {}_V j \quad r \sin \quad dV = \frac{1}{c^2} \ {}_V S \quad r \sin \quad dV$ = **total angular momentum**.

Quantity $F = \frac{Q^2}{L} \frac{}{} = \frac{Q^2}{L}$ is dimensionless and can be determined by **purely mathematical** procedure involving **strictly no physical parameter**.

Compare result with so-called **fine-structure constant**

$F = \frac{Q^2}{2h\ c} = \frac{Q^2}{2h} \frac{}{} \quad \frac{1}{137}$, Q= electron charge,

h = Planck constant, electron spin = $\frac{h}{4} = \frac{1}{2}\hbar$.

Is **analogy** between F and F purely **accidental**

or hint for valid **electron model**?

Important: Determine **numerical value** of F.

Also of interest: Reoccuring debate: is F time independent?

Compare result **with** double nature of number , e.g.:

physical: $= \frac{\text{circumference}}{\text{diameter}}$, mathematical: $= _{-} \frac{dx}{1+x^2}$ etc.

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Field moving with speed $v = c$ **in unique direction** (x - axis):

Know: $v = c$ $\quad$ $\mathbf{E}^T\mathbf{H} = 0$, $\quad E^2 = \ H^2$

$S_x \quad 0$, $\quad S_y = S_z = 0 \qquad E_x = H_x = 0$

Altogether: $\quad \overline{\ }\,E_y = \overline{\ }\,H_z$, $\quad \overline{\ }\,E_z = - \ \overline{\ }\,H_y$

Then: $\quad \frac{}{t} E_y + c \frac{}{x} E_y = \frac{}{t} E_z + c \frac{}{x} E_z = \frac{}{y} E_z - \frac{}{z} E_y = 0$

$i_y = i_z = 0$, $\quad i_x = cq \quad q \quad \left(\frac{}{y} E_y + \frac{}{z} E_z\right)$

Require: E_y and E_z **must vanish** at infinity.

Solution:

$$E_y = \frac{1}{2} \quad - \quad - \quad \frac{(y - y)\, q\,(x - ct, y, z)}{d^2}\, dy\, dz$$

$$E_z = \frac{1}{2} \quad - \quad - \quad \frac{(z - z)\, q\,(x - ct, y, z)}{d^2}\, dy\, dz$$

$d = \overline{(y - y)^2 + (z - z)^2}$ = distance $(y, z), (y\ , z\ )$ for x , t fixed.

Field **locally planar**, **transversal** , propagates **unidirectionally**.

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Field obtained has properties of **photon**:

1. Propagates in **single direction**, with **speed** of **light** c.
2. Field is **transversal** and effectively **polarized** (linear, circular).
3. Energy $W = \tilde{\hbar}\,\Omega$ where $\tilde{\hbar}$ = const., Ω = **nominal frequency**.
   Plausible: $\tilde{\hbar} = \hbar$.
4. Reference **frame** RF' **moving** with constant $\mathbf{v_o}$:
   transforms **given field** into **new field** of **exactly same nature**.
5. Exhibits known **relativistic Doppler** effects:
   longitudinal as well as **lateral**.
6. Its **momentum** is equal to W/c.
7. Its **rest energy** and its **rest mass** are equal to **zero**.
8. Field is **electrically neutral**: total charge Q = 0.
9. **Magnetic moment** is zero.

10. **Rotating** or **oscillating** charge densities compatible with:

total **positive** and total **negative charges** remain **constant**.

Makes **plausible**: **annihilation** $e^- + e^+$ **,**

pair production (e^-, e^+).

11. Field is **localized**: q concentrated in small volume.

Hence, **model** behaves like **particle**.

12. Is like a general **modulated signal**, suppressed carrier,

where **nominal frequency** = **carrier frequency**.

Hence, **model** behaves like **wave**.

13. From 11. and 12. **conclude**:

Is simultaneously **particle and wave**.

Obtain natural explanation of **wave-particle duality**.

14. **Uncertainty**: x/2) (p/2) $\hbar$/2 , where

x = spread in **length** = cΔt,

p= spread of **momentum** = $\hbar$/c, = **bandwidth**.

15. In dispersive media, travels with 2 **distinct velocities**:

Carrier with **phase** velocity, energy with **group** velocity.

16. Exhibits **gravitational red-shift** of same size

as that known from General Relativity.

17. Results from lateral Doppler effect appear

compatible with correct **deflection** by star.

Speculation. Δh = inherent inaccuracy of Planck “constant”.

Possibly, $\frac{h}{h} = \frac{\hbar}{\hbar} \quad (\frac{\quad}{\quad})^2$ where = (effective) bandwidth.

Question: For given , ideal configuration not unique?

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Movement of electromagnetic (EM) **particles** in **external EM field** and/or **gravitational field**.

- Desired **dynamic equations** follow by integrating flow equations of EM field over relevant volume and exploiting symmetry properties of model.

Find: $\frac{d\mathbf{J}_p}{dt} = \mathbf{F}_e$, $\frac{dW_p}{dt} = \mathbf{v}_p^T \mathbf{F}_e$, where

$\mathbf{J}_p$ = momentum, W_p = energy , $\mathbf{v}_p$ = velocity of particle

$\mathbf{F}_e$ = force on particle due to **e**xternal field.

In vector field derived from potential U:

External **EM** field $\mathbf{F}_e = -Q\nabla U$, $\mathbf{v}_p^T \mathbf{F}_e = -\frac{d(QU)}{dt}$,

External **gravitational** field: $\mathbf{F}_e = -M_p\nabla U$, $\mathbf{v}_p^T \mathbf{F}_e = -\frac{d(M_pU)}{dt}$,

where Q = **charge** , M_p = **relevant mass** of particle = $\frac{W_p}{c^2}$.

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Further properties of **electromagnetic** (EM) **particles**

1. Momentum/energy characterized **not** by **scalar** mass
   but by **matrix** (tensor) with circular symmetry,
   in fact by an **oblate spheroid**.
   Note: **Not** a **rigid** body, thus **not** simply a **gyroscope**.
2. In an **external** field, particle always assumes
   position requiring **minimum work/energy**.
   Corresponding **inertial** mass is $M = W/c^2$.
3. **Lateral** kinetic energy involves **mass** 2M , corresponding
   to double **gravitational** force (relevant for deflection ?).
4. **de Broglie** relation, **Schrödinger** equation, **relativistic** extension.

Nominal (mean) **values** of major **characteristics** of **rotating field** (like electron)

Start from

$$M_0 = \int_V m_0 \mathrm{d}V, \quad M_{c0} = \int_V m_{c0} \mathrm{d}V, \quad m_0 = 2m_{c0} = 2\frac{w_0}{c^2}$$

$$W = M_c c^2 = \int_V w \mathrm{d}V, \quad w = \frac{1+\beta^2}{\alpha^2} w_0 = \frac{w_0}{\alpha_c}, \quad W_0 = \int_V w_0 \mathrm{d}V$$

$$W_k = W - W_0 = \int_V w_k \mathrm{d}V, \quad w_k = \frac{2\beta^2}{\alpha^2} w_0 = \beta\beta_c w = \omega l$$

$$\beta_c = \frac{2\beta}{1+\beta^2}, \quad \omega = \frac{v}{R}$$

$$L = \int_V l \mathrm{d}V \quad l = Rj, \quad j = \frac{v}{\alpha^2} m_0 = \frac{v_c}{\alpha_c} m_{c0}$$

$R =$ distance from axis

For **determining nominal** $\overline{\alpha}, \overline{\beta}, \overline{\alpha}_c, \overline{\beta}_c, \overline{R}, \overline{v}, \overline{v}_c, \overline{\omega}$ **require**

$$W = c^2 M_c = \int_V \frac{1+\beta^2}{\alpha^2} w_0 \mathrm{d}V = \frac{1+\overline{\beta}^2}{\overline{\alpha}^2} \int_V w_0 \mathrm{d}V = \frac{1+\overline{\beta}^2}{\overline{\alpha}^2} W_0$$

$$= \int_V \frac{w_0}{\alpha_c} \mathrm{d}V = \frac{1}{\overline{\alpha}_c} \int_V w_0 \mathrm{d}V = \frac{1}{\overline{\alpha}_c} W_0 = \textbf{total energy} = 2L\Omega_g$$

$$L = \int_V \frac{2\beta}{c\alpha^2} R w_0 \mathrm{d}V = \frac{2}{c\overline{\alpha}^2} \overline{R} W_0$$

$$= \int_V \frac{\beta_c}{c\alpha_c} R w_0 \mathrm{d}V = \frac{\overline{\beta}_c}{c\overline{\alpha}_c} \overline{R} W_0 = \frac{\overline{\beta}_c}{c} \overline{R} W = \textbf{angular momentum} = \overline{R}\,\overline{J}$$

where $\overline{J} = L / \overline{R} =$ **nominal momentum**

$$\overline{\alpha} = \sqrt{1-\overline{\beta}^2}, \quad \overline{\alpha}_c = \sqrt{1-\overline{\beta}_c{}^2}, \quad \overline{v} = c\overline{\beta} = \overline{w}\overline{R}, \quad \overline{v}_c = c\overline{\beta}_c, \quad \Omega_g = \frac{c}{2\overline{R}\overline{\beta}_c}$$

In particular: $\overline{\beta}_c \overline{R} = \dfrac{L}{cM_c}, \quad \overline{\beta}_c = \dfrac{2\overline{\beta}}{1+\overline{\beta}^2}, \quad W_k = W - W_0 = \overline{\omega} L$

Summary of **nominal** values

Have obtained:

$\bar{\beta}, \quad \bar{\alpha} = \sqrt{1-\bar{\beta}^2}, \quad \bar{v} = c\bar{\beta}$ **nominal field velocity**

$\bar{\beta}_c, \quad \bar{\alpha}_c = \sqrt{1-\bar{\beta}_c^{\,2}}, \quad \bar{v}_c = c\bar{\beta}_c$ **nominal energy velocity**

$\bar{R} =$ **nominal radius** (distance from axis)

$\bar{\omega} =$ **nominal angular velocity**

Comments

1. Results hold **also if** field **not circularly symmetric**.
2. In view of their simple relationship to the basic parameters of the particle, the **nominal values** derived above are highly useful for **offering** wanted **insight**. Nevertheless, a **detailed** picture can **only** be gained **from** the full set of **PDE**s describing the device.

Assume now **field** to be a particle, indeed an **electron**.
Definitions correspond to those above, but for clarity add, if needed, subscripts "*e*" for "**e**lectron", "$_0$" for "at rest".
Obtain:

M_{e0} **= mass** of **e**lectron at **rest =** M_c **=** "**c**lassical" electron mass

$$W_{e0} = c^2 M_{e0} = \frac{2cL_e}{R_g} = 2L_e\Omega_g = \hbar\Omega_g$$ = **energy** of **e**lectron at **rest**

$$L_e = \frac{1}{2}cM_cR_g$$ = **angular momentum** of **e**lectron $= \frac{\hbar}{2}$

Have identified L_e with electron **spin,** defined Ω_g by

$$\Omega_g = \frac{c}{R_g}$$

Characteristic radius R_g to be explained hereafter.

Definition and properties of R_g, R_0, and $\overline{R}$:

$$R_g = 2R_0 = \frac{2L_e}{cM_{e0}} = \frac{\hbar}{cM_{e0}} = \sqrt{R_c R_B} = \textbf{characteristic radius}$$

$= \mathbf{g}$eometric mean of:

R_c = **classical electron radius**, R_B = **Bohr radius.**

$$\frac{R_c}{R_g} = \frac{R_g}{R_B} = F_s = \text{(Sommerfeld's) } \textbf{fine structure constant}$$

Obtain from above and with Ω as defined hereafter,

$$2\overline{v}_c\overline{R} = cR_g, \quad \frac{\overline{v}_c}{R_g} = \frac{c}{2\overline{R}} =: \Omega$$

and for nominal momentum

$$\overline{J}_e = \frac{L_e}{\overline{R}} = \overline{v}_c M_{e0}$$

Electron **cannot** possibly perfectly **admit** ideal configuration **as** assumed **in model**. In practice, therefore:

An **electron** consists of **two additively superposed fields**:
- **Prime field =** ideal field, satisfies original Maxwell's PDEs.
- **Co-field**: satisfies Maxwell's PDEs with **i** and q set to zero.

For co-field thus exists an EM (electromagnetic) **wave equation**

$$\Delta\psi = \frac{1}{c^2}\frac{\partial^2\psi}{\partial t^2}, \quad \Delta = \frac{\partial^2}{\partial x^2} + \frac{\partial^2}{\partial y^2} + \frac{\partial^2}{\partial z^2}$$

where ψ stands for any of the 6 components of **E** and **H**.

S**tability** implies: co-field, like prime field is **standing wave**.
Hence, there must exist a wavelength Λ such that

$$\frac{\Lambda}{2} = 2\pi\overline{R}, \quad \text{thus} \quad 4\pi\overline{R} = \Lambda$$

Recall: For basic wavelength Λ of (electromagnetic!) co-field:

$$\frac{\Lambda}{2} = 2\pi\overline{R}, \quad \text{thus} \quad \Lambda = 4\pi\overline{R}$$

Corresponding **wave number** K and **angular frequency** Ω:

$$K = \frac{2\pi}{\Lambda} = \frac{1}{2\overline{\overline{R}}} = \frac{\overline{v}_c}{cR_g} = \frac{\overline{v}_c M_{e0}}{2L_e}$$

$$\Omega = cK = \frac{c}{2\overline{\overline{R}}} = \frac{\overline{v}_c}{R_g}, \quad \Omega \text{ being as defined before.}$$

For **nominal momentum** find then

$$\overline{J}_e = \frac{L_e}{\overline{\overline{R}}} = 2L_e K$$

This immediately yields

$$\overline{J}_e = \hbar K$$

thus the **de Broglie relation**.

Recall:

$$\Delta\psi - \frac{1}{c^2}\frac{\partial^2\psi}{\partial t^2} = 0$$

Assume $\psi = \Psi e^{i\Omega t}$. Find time-independent equation (Helmholtz equation)

$$\Delta\Psi + K^2\Psi = 0 \qquad (1)$$

where $$K = \frac{1}{2\overline{R}} = \frac{\overline{v}_c}{cR_g}, \quad K^2 = \frac{\overline{v}_c^2}{c^2 R_g^2} = \frac{M_{e0}^2 \overline{v}_c^2}{4L_e^2} = \frac{M_{e0}^2 \overline{v}_c^2}{\hbar^2}$$

If v_c were **non-relativistic** could write

$$W_{ek} = \frac{1}{2}M_{e0}^2 \overline{v}_c^2, \quad K^2 = 2\frac{M_{e0}}{\hbar^2}W_{ek}, \quad W_{pk} = \text{kinetic energy},$$

(1) exactly like **Schrödinger equation** (yet: isolated electron!).

In **reality**: $\overline{v}_c$ **relativistic**, yet (1) remains being a valid time-independent Schrödinger-type equation.

Electron in atomic shell

Presence of central potential does **not affect validity** of above **general theory**. However:

$\bar{v}_c$ must be replaced by v_e = energy velocity electron: $v_e << \bar{v}_c$
$\bar{R}$ will be larger (careful: change of notation not needed).
R_g: imposed by given energy and angular momentum.

If v_e is indeed **non-relativistic**, obtain

$$\Delta\Psi + K^2\Psi = 0 \qquad (2)$$

$$K^2 = 2\frac{M_{e0}}{\hbar^2}W_{ek}, \quad W_{ek} = \frac{1}{2}M_{e0}^2 v_e^2, \quad W_{ek} = \text{kinetic energy},$$

Then (2) is precisely time-independent **Schrödinger equation**.
Relativistic case: omit non-relativistic approximation.

Recall:

$$\Delta\Psi + K^2\Psi = 0 \qquad (2)$$

$$K^2 = 2\frac{M_{e0}}{\hbar^2}W_{ek}, \quad W_{ek} = \text{kinetic energy},$$

These relations depend only on electron at rest and its kinetic energy, not on $\overline{R}$. They thus do not contain any quantity referring to a rotational behaviour and may therefore be assumed to remain valid for movements of, say, linear type.

Consequently, the time-independent **Schrödinger equation** applies also in cases like quantum wells etc.
The field of which the electron consists then appears to be stretched out.

Relativistic case: omit non-relativistic approximation.

Comments:

- **All results** obtained exclusively **from Maxwell**'s equations, assuming their validity also at smallest dimensions, thus also inside of the electromagnetic elementary particles.

- The **Schrödinger equation** is **based on nominal** field values only. It therefore does not describe the detailed behaviour of the main field inside of a particle.

- The **Schrödinger function** describes a field of **electromagnetic** (EM) nature, i.e., the co-field, and is thus in fact deterministic. It is therefore **nowhere** of **intrinsic probabilistic** nature, **as** assumed by the so-called **Copenhagen** interpretation.

- For a given EM particle there exist an uncountable infinity of possible co-fields. In that sense we are dealing with a problem of **extrinsic** probabilistic nature.

Speculations and **comments**:

1.Elementary particles: **compressed fields**,
governed by **nonlinear PDE**s (partial differential equations).

2. Correspondingly for particles **composed** of elementary ones.

3. Only specific configurations are stable: **quantum states**.

4. **Quantum jumps**: transitions between stable states,
governed by **dynamic processes** in field.

5. **Comparison** with **digital world**: digital communications,
digital signal processing, digital control engineering etc.;
digital computers, computer science;
worldwide, highly-interconnected internet.
In all these, **may** fully **ignore** existence of switching **dynamics**.
Yet: **IC designers** must be highly **aware** of many major **details**.

6. Position **space** (= space spanned by position coordinates) **is where** there is electromagnetic (EM) **field**.
7. Most EM fields not compressed but highly thinned out,

   thus **vagabonding** with field/energy velocity < c.

   Dark matter ?
8. EM particles: condensed **turbulences** in EM sea.
9. In particles: exist **fluctuations** around equilibrium, **statistical**.
10. Solves **wave-particle duality**.
11. In **presence** of other **forces**, the field of a **particle** will be **distorted**, **spread** out, or even **torn apart**.

    Could explain **quantum paradoxes** and other properties.

    Examples: double slit experiment,

    behaviour in quantum wells and atomic shells.

12. How ensure **stability** of a **field** configuration,

thus of given multidimensional (MD) system ?

Needed: **generalization** of 2nd **method** of **Lyapunov**.

13. For achieving **global stability** recall some basic principles of

wave-digital method for robust numerical integration:

a) Given **physically passive** system S in t, **r** = $(x, y, z)^T$.

Transform t, **r** **t** = $(t_1,...,t_4)^T$, t time-like, = 1 to 4.

Thus, S new system S'. Can make S' **MD causal** (all v c).

b) Find **MD Kirchhoff circuit** K representing S'.

Require K to be internally MD passive.

Yields **W** = $(W_1 ,...,W_4)^T$ = **W**(**t**) ≥ **0** ∀ field variable values.

W = stored energy associated with t , = 1 to 4 .

This **W** is desired **MD Lyapunov vector function**.

14. **If** system is **nonlinear** etc., **global** stability **not sufficient**.

How ensure also **local stability** of a **field** configuration ?

Two possible approaches:

a) In neighborhood of any relevant point

approximate system by a **linear constant** system.

Determine **system determinant**.

Apply theory of multidimensional (MD) Hurwitz polynomials:

MD **scattering Hurwitz polynomials** etc.

b) Else: approximate by **slowly varying** system.

Represent this **by new** MD Kirchhoff **circuit**.

Ensure its internal MD passivity.

Yields further MD **Lyapunov vector function**.

15. Apply **Schrödinger-type** equation to **isolated electron**.
Examine consequences for determining
- complete solution of ideal field (main field),
- fine structure constant,
- gyromagnetic ratio.

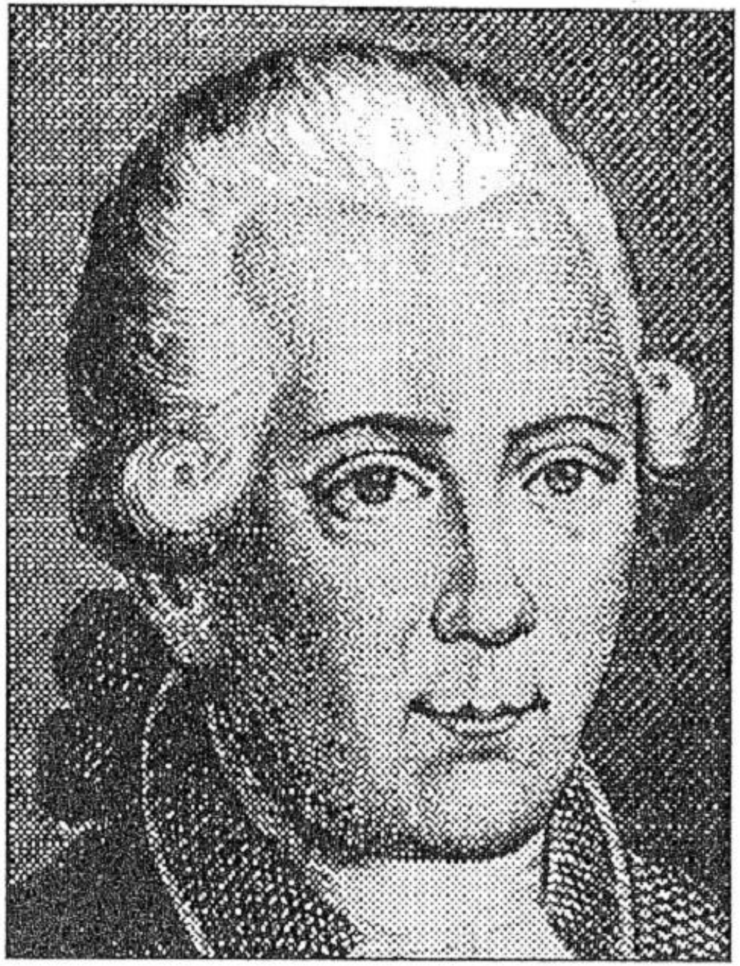
16. For basal field establish full **equivalence** between complete set of **flow equations** and **Maxwell**'s equations (done).

17. **Generalize** complete flow equations to **include gravitation**.
Find: **Gravitational** field is **accompanied by** a **partner field**, like electric field is accompanied by its partner, the magnetic field.
Basic ideas confirmed, details need to be worked out.
Difficult but challenging task ahead.

Wörtlich

Was jedermann für ausgemacht hält, verdient am meisten untersucht zu werden.

Georg Ch. Lichtenberg
Physiker und Schriftsteller



"What everybody takes as assured, deserves most to be investigated."

Georg Ch. Lichtenberg, physicist and writer, 1742-1799