

$$\rho(\mathbf{r}) = \sum_{\alpha} q_{\alpha} \delta^{(3)}(\mathbf{r} - \mathbf{r}_{\alpha}) \quad (1)$$

$$\nabla \cdot \vec{j} + \frac{\partial \rho}{\partial t} = 0 \quad (2)$$

$$\begin{aligned} \mathbf{F} &= q(\mathbf{E} + \mathbf{v} \times \mathbf{B}) \\ \mathbf{F} &= \int \rho d^3r (\mathbf{E} + \mathbf{v} \times \mathbf{B}) \\ &= \int (\rho \mathbf{E} + \mathbf{j} \times \mathbf{B}) d^3r \end{aligned} \quad (3)$$

$$\mathbf{p} = \int_V \rho(\mathbf{r}) \mathbf{r} dV \quad (4)$$

$$\phi = \frac{1}{4\pi\epsilon_0} \int_V \frac{\rho(\mathbf{r}')}{|\mathbf{r} - \mathbf{r}'|} dV' \quad (5)$$

$$\phi = \frac{1}{4\pi\epsilon_0} \left[ \frac{Q}{r} + \frac{\mathbf{r} \cdot \mathbf{p}}{r^3} + \frac{x_i D_{ij} x_j}{2r^5} \right] \quad (6)$$

$$\mathbf{E}(\mathbf{r}) = \frac{1}{4\pi\epsilon_0} \int \frac{\rho(\mathbf{r}') d^3r'}{|\mathbf{r} - \mathbf{r}'|^3} (\mathbf{r} - \mathbf{r}') \quad (7)$$

$$\begin{aligned} D_{ij} &= \int \rho(\mathbf{r}) (3x_i x_j - \delta_{ij} r^2) dV \\ D_{ij} &= \sum_{\alpha} q_{\alpha} (3x_i^{(\alpha)} x_j^{(\alpha)} - \delta_{ij} (r^{(\alpha)})^2); \quad \text{Tr } \hat{D} = 0 \end{aligned} \quad (8)$$

$$\mathbf{E} = -\nabla \phi \quad (9)$$

$$\mathbf{j} = \rho \mathbf{v} \quad (10)$$

$$\mathbf{A}(\mathbf{r}) = \frac{\mu_0}{4\pi} \int \frac{\mathbf{j}(\mathbf{r}')}{|\mathbf{r} - \mathbf{r}'|} dV' \quad (11)$$

$$\mathbf{A}(\mathbf{r}) = \frac{\mu_0}{4\pi} \frac{\mathbf{m} \times \mathbf{r}}{r^3} \quad (12)$$

$$\mathbf{m}(\mathbf{r}) = \frac{1}{2} \int \mathbf{r} \times \mathbf{j}(\mathbf{r}) dV \quad (13)$$

$$\mathbf{B}(\mathbf{r}) = \nabla \times \mathbf{A} = \frac{\mu_0}{4\pi} \int \frac{\mathbf{j}(\mathbf{r}') \times (\mathbf{r} - \mathbf{r}')}{|\mathbf{r} - \mathbf{r}'|^3} dV' \quad (14)$$

$$\mathbf{E} = -\frac{\partial \mathbf{A}}{\partial t} - \nabla \phi \quad (15)$$

$$\nabla \cdot \mathbf{A} + \frac{1}{c^2} \frac{\partial \phi}{\partial t} = 0 \quad (16)$$

$$\nabla^2 \phi - \frac{1}{c^2} \frac{\partial^2 \phi}{\partial t^2} = -\frac{\rho}{\epsilon_0} \quad (16)$$

$$\nabla^2 \mathbf{A} - \frac{1}{c^2} \frac{\partial^2 \mathbf{A}}{\partial t^2} = -\mu_0 \mathbf{j} \quad (17)$$

$$\langle \rho \rangle = \frac{1}{T} \int_0^T \rho dt \quad (17)$$

$$\nabla^2 \phi - \frac{1}{c^2} \frac{\partial^2 \phi}{\partial t^2} = -\frac{1}{\epsilon_0} \rho \quad (18)$$

$$\nabla^2 \mathbf{A} - \frac{1}{c^2} \frac{\partial^2 \mathbf{A}}{\partial t^2} = -\mu_0 \mathbf{j} \quad (19)$$

$$\begin{aligned} D_{2n} - D_{1n} &= \sigma \\ B_{2n} - B_{1n} &= 0 \\ P_{2n} - P_{1n} &= -\sigma_{vez} \\ E_{2n} - E_{1n} &= \frac{1}{\epsilon_0} \sigma \\ E_{2t} - E_{1t} &= 0 \\ \mathbf{n} \times (\mathbf{H}_2 - \mathbf{H}_1) &= \mathbf{i} \\ M_{2t} - M_{1t} &= \mathbf{i}_{vez} \times \mathbf{n} \end{aligned} \quad (20)$$

$$\begin{aligned} \nabla \cdot \vec{E} &= \frac{\rho}{\epsilon_0} \\ \nabla \cdot \vec{B} &= 0 \end{aligned} \quad (21)$$

$$\begin{aligned} \nabla \times \mathbf{E} &= -\frac{\partial \mathbf{B}}{\partial t} \\ \nabla \times \mathbf{B} &= \mu_0 \left( \mathbf{j} + \epsilon_0 \frac{\partial \mathbf{E}}{\partial t} \right) \end{aligned} \quad (21)$$

$$\begin{aligned} \nabla \cdot \vec{D} &= \rho + \rho_{ext} \\ \nabla \cdot \vec{B} &= 0 \end{aligned} \quad (22)$$

$$\begin{aligned} \nabla \times \mathbf{E} &= -\frac{\partial \mathbf{B}}{\partial t} \\ \nabla \times \mathbf{H} &= \mathbf{j} + \mathbf{j}_{ext} + \frac{\partial \mathbf{D}}{\partial t} \end{aligned} \quad (22)$$

$$q = UC = U\epsilon_0 \frac{S}{d} \quad (23)$$

$$\frac{d}{dt} \left( \sum_n \epsilon_n + \underbrace{\int_V d^3r \left( \frac{1}{2} \mathbf{D} \cdot \mathbf{E} + \frac{1}{2} \mathbf{H} \cdot \mathbf{B} \right)}_{W_{em}} \right) \quad (24)$$

$$\begin{aligned} &= -\oint_{\partial S} \mathbf{S}_p d\mathbf{S} \\ \frac{d}{dt} \left( \sum_n \epsilon_n \right) &= \int d^3r \mathbf{j} \cdot \mathbf{E} \end{aligned} \quad (24)$$

$$\begin{aligned} \mathbf{S}_p &= \mathbf{E} \times \mathbf{H} \\ \mathbf{g} &= \frac{\mathbf{S}_p}{c^2} \quad \text{- gustina impulsa} \end{aligned} \quad (25)$$

$$\mathbf{L} = \int \mathbf{r} \times \mathbf{g} dV \quad (26)$$

$$\begin{aligned} &\frac{d}{dt} \left[ \sum_{\alpha} \mathbf{p}_{\alpha} + \int d^3r (\mathbf{D} \times \mathbf{B}) \right] \\ &= -\frac{1}{2} \int d^3r (\epsilon_0 \mathbf{E}^2 \nabla \epsilon_r + \mu_0 \mathbf{H}^2 \nabla \mu_r) = \oint_S \hat{T} d\mathbf{S} \\ \hat{T} &= |\mathbf{E}|^2 |\mathbf{D}| + |\mathbf{H}|^2 |\mathbf{B}| - \frac{1}{2} (\mathbf{E} \cdot \mathbf{D} + \mathbf{H} \cdot \mathbf{B}) \hat{I} \end{aligned} \quad (27)$$

$$V^{\mu} = \left( \frac{c}{\sqrt{1 - \frac{v^2}{c^2}}}, \frac{\mathbf{v}}{\sqrt{1 - \frac{v^2}{c^2}}} \right) \quad (28)$$

$$P^{\mu} = mV^{\mu} = \left( \frac{E}{c}, \mathbf{p} \right) \quad (29)$$

$$\mathcal{A}^{\mu} = \frac{dV^{\mu}}{d\tau} = \left( \gamma \frac{d\gamma}{dt} \mathbf{v} + \gamma^2 \mathbf{a} \right) \quad (30)$$

$$\mathcal{F}^{\mu} = \left( \frac{\mathbf{v} \cdot \mathbf{F}}{c \sqrt{1 - \frac{v^2}{c^2}}}, \frac{\mathbf{F}}{\sqrt{1 - \frac{v^2}{c^2}}} \right) \quad (31)$$

$$\begin{aligned} \mathbf{E}'_{\parallel} &= \mathbf{R}_{\parallel} \\ \mathbf{E}'_{\perp} &= \frac{\mathbf{E}_{\perp} + \mathbf{v} \times \mathbf{B}_{\perp}}{\sqrt{1 - \frac{v^2}{c^2}}} \\ \mathbf{B}'_{\parallel} &= \mathbf{B}_{\parallel} \\ \mathbf{B}'_{\perp} &= \frac{\mathbf{B}_{\perp} - \frac{1}{c^2} \mathbf{v} \times \mathbf{E}_{\perp}}{\sqrt{1 - \frac{v^2}{c^2}}} \end{aligned} \quad (32)$$

$$\mathbf{E}' = \gamma(\mathbf{E} + \mathbf{v} \times \mathbf{B}) - \frac{\gamma^2}{c^2(1 + \gamma)} (\mathbf{v} \cdot \mathbf{E}) \mathbf{v} \quad (33)$$

$$\mathbf{B}' = \gamma(\mathbf{E} + \frac{1}{c^2} \mathbf{v} \times \mathbf{B}) - \frac{\gamma^2}{c^2(1 + \gamma)} (\mathbf{v} \cdot \mathbf{B}) \mathbf{v} \quad (33)$$

$$\begin{pmatrix} x'^0 \\ x'^1 \\ x'^2 \\ x'^3 \end{pmatrix} = \underbrace{\begin{pmatrix} \gamma & -\beta\gamma & 0 & 0 \\ -\beta\gamma & \gamma & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{pmatrix}}_{\Lambda^{\mu}_{\nu}} \begin{pmatrix} x^0 \\ x^1 \\ x^2 \\ x^3 \end{pmatrix} \quad (34)$$

$$g_{\mu\nu} = \begin{pmatrix} 1 & 0 & 0 & 0 \\ 0 & -1 & 0 & 0 \\ 0 & 0 & -1 & 0 \\ 0 & 0 & 0 & -1 \end{pmatrix} \quad (35)$$

$$\frac{\partial}{\partial x^{\mu}} = \left( \frac{1}{c} \frac{\partial}{\partial t}, \nabla \right) \quad (36)$$

$$j^{\mu} = (c\rho, \mathbf{j} = \rho \mathbf{v}) \quad (37)$$

$$A^{\mu} = \left( \frac{\phi}{c}, \mathbf{A} \right) \quad (38)$$

$$\square A^{\mu} = \mu_0 j^{\mu} \quad (39)$$

$$F^{\mu\nu} = \partial^{\mu} A^{\nu} - \partial^{\nu} A^{\mu} \quad (40)$$

$$F^{\mu\nu} = \begin{pmatrix} 0 & -\frac{E_x}{c} & -\frac{E_y}{c} & -\frac{E_z}{c} \\ \frac{E_x}{c} & 0 & -B_z & B_y \\ \frac{E_y}{c} & B_z & 0 & -B_x \\ \frac{E_z}{c} & -B_y & B_x & 0 \end{pmatrix} \quad (41)$$

$$F'^{\mu\nu} = (\Lambda F \Lambda^T)^{\mu\nu} \quad (42)$$

$$\begin{aligned} \frac{d\mathbf{p}}{dt} &= q(\mathbf{E} + \mathbf{v} \times \mathbf{B}) \\ \underbrace{\frac{d}{dt} \left( \frac{mc^2}{\sqrt{1 - \frac{v^2}{c^2}}} \right)}_E &= \mathbf{v} \cdot \mathbf{F} = q\mathbf{v} \cdot \mathbf{E} \end{aligned} \quad (43)$$

$$E^2 = c^2 p^2 + m^2 c^4 \quad (44)$$

$$\frac{d}{d\tau} \left( \frac{\partial \tilde{L}}{\partial u^{\alpha}} \right) - \frac{\partial \tilde{L}}{\partial x^{\alpha}} = 0 \quad (45)$$

$$\begin{aligned} \frac{\partial u^{\mu}}{\partial u^{\alpha}} &= \delta^{\mu}_{\alpha} \\ \frac{\partial u^{\mu}}{\partial u_{\alpha}} &= g^{\mu\alpha} \end{aligned} \quad (46)$$

$$\begin{aligned} S &= \int (-mc ds - q A^{\mu} dx_{\mu}) + S_f \\ ds &= \sqrt{g_{\mu\nu} \frac{dx^{\mu}}{d\tau} \frac{dx^{\nu}}{d\tau}} d\tau \\ ds &= c d\tau = c \sqrt{1 - \frac{v^2}{c^2}} dt \\ A^{\mu} dx_{\mu} &= (\phi - \mathbf{A} \cdot \mathbf{v}) dt \end{aligned} \quad (47)$$