$\boxed{\text{Vzorečky}}$

$$\frac{1}{4\pi}\begin{pmatrix} cE_\nu \\ \vec{F}_\nu \\ c\overleftrightarrow{P} \end{pmatrix} = \frac{1}{4\pi}\oint \begin{pmatrix} 1 \\ \vec{n} \\ \vec{n}\otimes\vec{n} \end{pmatrix} I_\nu \, d\omega$$

$$I = ch\nu f_N = \frac{h^4\nu^3}{c^2} f_R$$

$$E_\nu = \frac{4\pi}{c} J_\nu \,,\; E_R = \frac{\sigma}{c} T^4$$

$$H_\nu = \frac{1}{4\pi} F_\nu \,,\; p = \frac{1}{3} E_R$$

$$J_\nu(z) = \frac{1}{2}\int_{-1}^{1} I_\nu(z,\mu)\, d\mu$$

$$p_R = \frac{4\pi}{c} K \,,\; E_R = \frac{4\pi}{c} J \,,\; f_\nu^k = \frac{K_\nu}{J_\nu}$$

$$H_\nu(z) = \frac{1}{2}\int_{-1}^{1} I_\nu(z,\mu)\,\mu\, d\mu$$

$$\overleftrightarrow{P} = \mathrm{diag}(p_R) - \frac{1}{2}\mathrm{diag}(3p_R - E_R)$$

$$K_\nu(z) = \frac{1}{2}\int_{-1}^{1} I_\nu(z,\mu)\,\mu^2\, d\mu$$

$$\tilde{I}_\nu = \frac{1}{\pi}\int_0^{2\pi}\int_{-\frac{\pi}{2}}^{\frac{\pi}{2}} I(\theta,\varphi) \sin\theta\cos\theta\, d\theta\, d\varphi$$

$$P_I = E_1^2 + E_2^2$$

$$P_I^2 = P_Q^2 + P_U^2 + P_V^2 \qquad p = \frac{\sqrt{P_Q^2 + P_U^2 + P_I^2}}{P_I}$$

$$P_Q = E_1^2 - E_2^2$$

$$P_U = 2E_1E_2\cos(\phi_1 - \phi_2)$$

$$I, Q, U, V = \frac{c}{8\pi} P_{I,Q,U,C}$$

$$P_V = 2E_1E_2\sin(\phi_1 - \phi_2)$$

$$\left(\frac{1}{c}\frac{\partial}{\partial t} + \frac{\partial}{\partial s}\right) I_\nu(\vec{r},\vec{n}) = \eta_\nu(\vec{r},\vec{n}) - \chi_\nu(\vec{r},\vec{n}) I_\nu(\vec{r},\vec{n})$$

$$d\tau_\nu(z) = -\chi_\nu(z)\, dz$$

$$\mu\frac{dI_\nu(z,\mu)}{dz} = \eta_\nu(z,\mu) - \chi_\nu(z,\nu) I_\nu(z,\mu)$$

$$S = \frac{\eta}{\chi}$$

$$\left(\mu\frac{\partial}{\partial r} - \frac{1-\mu^2}{r}\frac{\partial}{\partial r}\right) I_\nu(r,\mu) = \eta_\nu(r,\mu) - \chi_\nu(r,\mu) I_\nu(r,\mu)$$

$$\mu\frac{dI}{d\tau} = I - S$$

$$\frac{\partial E_\nu}{\partial t} + \vec{\nabla}\cdot\vec{F}_\nu = \oint(\eta_\nu - \chi_\nu I_\nu)\, d\omega = 4\pi(\eta_\nu - \chi_\nu J_\nu)$$

$$\frac{dH_\nu}{dz} = \eta_\nu - \chi_\nu J_\nu \,,\; \frac{dK_\nu}{dz} = -\chi_\nu H_\nu$$

$$\frac{1}{c^2}\frac{\partial \vec{F}_\nu}{\partial t} + \vec{\nabla}\overleftrightarrow{P}_\nu = \frac{1}{c}\oint \vec{n}(\eta_\nu - \chi_\nu I_\nu)\, d\omega = -\frac{1}{c}\chi_\nu F_\nu$$

$$\frac{d^2(f_\nu^k J_\nu)}{d\tau_\nu^2} = J_\nu - S_\nu$$

$$\left(\frac{n_i}{N}\right)^* = \frac{g_i}{U^*} e^{-\frac{\varepsilon_i}{kT}} \qquad U^* = \sum_i g_i e^{-\frac{\varepsilon_i}{kT}} \qquad \left(\frac{n_u}{n_l}\right)^* = \frac{g_u}{g_l} e^{-\frac{h\nu}{kT}}$$

$$\frac{n^*_{0,j+1}}{n^*_{0,j}} = \frac{g_{0,j+1} \cdot g_{e^-}(v)}{g_{0,j}} e^{-\frac{\varepsilon_{I,j} + \frac{1}{2} m v^2}{kT}} = \frac{g_{0,j+1}}{g_{0,j}} \frac{2}{n_{e^-}} \left(\frac{2\pi m_e kT}{h^2}\right)^{3/2} e^{-\frac{\varepsilon_{I,j}}{kT}}$$

$$n^*_{ij} = n_{0,j+1} n_e(v) \Phi_{ij}(T) \qquad \Phi_{ij}(T) = \frac{g_{i,j}}{g_{0,j+1}} C_I T^{-3/2} e^{\frac{\varepsilon_{I,j} - \varepsilon_{i,j}}{kT}}$$

$$C_I = \left(\frac{h^2}{2\pi m_e kT}\right)^{3/2}$$

čáry:

$$r_{lu} = n_l B_{lu} I$$

$$r^{stim}_{ul} = n_u B_{ul} I$$

$$r^{spont}_{ul} = n_u A_{ul}$$

kontinuum:

$$r_{bf} = n_0 p_\nu I \, d\nu$$

$$r^{stim}_{fb} = n_1 n_e(v) G(v) I \, v \, dv$$

$$r^{spont}_{fb} = n_1 n_e(v) F(v) \, v \, dv$$

$$A_{ul} = \frac{2h\nu^3}{c^2} B_{ul}$$

$$g_l B_{lu} = g_u B_{ul}$$

$$F(v) = \frac{2h\nu^3}{c^2} G(v)$$

$$G(v) = \frac{m_e}{h} \left[\frac{n_0^*}{n_1^* n_e^*(v)}\right] p_\nu e^{-\frac{h\nu}{kT}}$$

makroskopicky: $\sigma_{cl} = \frac{\pi e^2}{m_e c}$, $f_{lu} = \frac{\alpha_{lu}}{\sigma_{cl}}$

$$\chi(\nu) = \frac{h\nu}{4\pi}\left(\Phi(\nu) n_l B_{lu} - \Psi^{stim}(\nu) n_u B_{ul}\right) \qquad \chi_{bf}(\nu) = n_0^* \alpha_{bf}(\nu) \left(1 - e^{-\frac{h\nu}{kT}}\right)$$

$$\eta(\nu) = \frac{h\nu}{4\pi} \Psi^{spont}(\nu) n_u A_{ul}$$

$$\eta_{fb}(\nu) = n_0^* \alpha_{bf}(\nu) \left(1 - e^{-\frac{h\nu}{kT}}\right) B_\nu(T) d\nu$$

formální:

$$I(\tau_1, \mu) = I(\tau_2, \mu) e^{-\frac{\tau_2 - \tau_1}{\mu}} + \int_{\tau_1}^{\tau_2} S(t) e^{-\frac{t - \tau_1}{\mu}} \frac{dt}{\mu}$$

difuzní:

$$I_\nu(\tau_\nu, \mu) \approx B_\nu + \mu \frac{dB_\nu}{d\tau_\nu}$$

$$J_\nu = \frac{1}{2} \int_0^\infty S_\nu(t) E_1(|t - \tau_\nu|) dt \qquad E_n(x) = \int_1^\infty e^{-xt} t^{-n} dt \implies J_\nu = \Lambda[S_\nu(t)]$$

$$\frac{1}{\chi_R} \frac{dB}{dT} = \int_0^\infty \frac{1}{\chi_\nu} \frac{dB_\nu}{dT} d\nu$$

$$j_{\mu\nu} = \frac{1}{2}\left[I(+\mu, \nu) + I(-\mu, \nu)\right] \qquad \mu \frac{dh_{\mu\nu}}{d\tau_\nu} = j_{\mu\nu} - S_\nu$$

$$\frac{d^2 j_{\mu\nu}}{d\tau_\nu^2} = j_{\mu\nu} - S_\nu$$

$$h_{\mu\nu} = \frac{1}{2}\left[I(+\mu, \nu) - I(-\mu, \nu)\right] \qquad \mu \frac{dj_{\mu\nu}}{d\tau_\nu} = h_{\mu\nu}$$

Vzorečky 2

rozptyl:

$$\eta^s = \sigma_0(\vec{r}) \oint \frac{d\omega}{4\pi} \int_0^\infty R(\vec{n},\nu,\vec{n}',\nu')\, I\, d\nu'$$

$$L(x,\gamma) = \frac{\gamma}{\pi(x^2+\gamma^2)} \qquad x = \frac{E-E_n}{h} \qquad \gamma = \frac{\Gamma_{ln}}{4\pi}$$

$$g(\vec{n},\vec{n}') = \frac{3}{2}(1+\cos\phi)$$ – elipsa

$$\sigma_{e^-} = \frac{8}{3}\frac{\pi e^4}{m_e^2 c^2}$$ – na valných

$$\sigma_{e^-} = \frac{8\pi e^4}{3 m_e^2 c^2} f_{ij} \frac{\omega^4}{(\omega_{ij}^2-\omega^2)}, \quad \omega = 2\pi\nu$$

struktura:

$$\vec{j} = \vec{l} + \vec{s} \qquad j \in \langle |l-s|, |l+s| \rangle$$

$$\Delta l = \pm 1$$

$$\Delta m_l = 0, \pm 1$$

$$\Delta j = 0, \pm 1 \quad \text{kromě } j=0 \leftrightarrow j'=0$$

LS

$$\vec{L} = \sum_i l_i$$

$$\vec{S} = \sum_i s_i$$

$$\vec{J} = \vec{L} + \vec{S}$$

jj

$$\vec{j}_i = \vec{l}_i + \vec{s}_i$$

$$\vec{J} = \sum_i j_i$$

Sobbolevova aproximace: $\tau(\vec{n}) = \dfrac{\chi_L c}{\nu_0 |\vec{n}\cdot\vec{\nabla}\vec{v}\cdot\vec{n}|} \Rightarrow \dfrac{\nu_0}{c}|\vec{n}\cdot\vec{\nabla}\vec{v}\cdot\vec{n}| \dfrac{dI}{dy} = \chi_L(S_L - I)$

$$\bar{I}(\vec{n}) = I_c \beta(\vec{n}) + S_L[1-\beta(\vec{n})], \quad \beta(\vec{n}) = \frac{1-e^{-\tau(\vec{n})}}{\tau(\vec{n})}$$

$$\bar{J} = \frac{1}{4\pi}\oint I_c \beta(\vec{n})\, d\omega + S_L(1-\beta), \quad \beta = \frac{1}{4\pi}\oint \frac{1-e^{-\tau}}{\tau}\, d\omega$$

$$\Delta l_s = \frac{c\,\Delta\nu_0}{\nu_0 \frac{dv_r}{dr}} \approx \frac{v_{th}}{v_0} l_0$$

$$\tau_{th} = \frac{1}{\sqrt{\varepsilon_\nu}}$$

rozptyl podruhé: – termalizační délka $L^2 = \sum_i^N \langle l_i \rangle \approx N l^2 \qquad L = \dfrac{l_\nu}{\sqrt{\varepsilon_\nu}}$

$$l_\nu = \frac{1}{\kappa_\nu + \sigma_\nu}, \quad \varepsilon_\nu = \frac{\kappa_\nu}{\kappa_\nu + \sigma_\nu}, \quad S_\nu = \frac{\kappa_\nu B_\nu + \sigma_\nu J_\nu}{\kappa_\nu + \sigma_\nu} = \varepsilon_\nu B_\nu + (1-\varepsilon_\nu) J_\nu$$

– v čarách: $\chi_\nu = \chi_c + \chi_L \Phi_\nu, \quad \eta_\nu = \chi_c B_\nu + \chi_L \Phi_\nu \left[\varepsilon_\nu B_\nu + (1-\varepsilon_\nu) \int J_{\nu'} \phi_{\nu'} d\nu'\right]$

$$S_\nu = \xi_\nu B_\nu + (1-\xi_\nu) \int J_{\nu'} \phi_{\nu'} d\nu' \qquad \xi = \frac{r + \varepsilon \phi_\nu}{r + \phi_\nu}, \quad r = \frac{\chi_c}{\chi_L}$$

$$J_\nu = \Lambda_\nu[S_\nu] = \Lambda_\nu[(1-\varepsilon)J_\nu] + \Lambda_\nu[\varepsilon B_\nu]$$