$$y = \frac{1}{eE}\sqrt{\mathcal{E}_0^2 + c^2 e^2 E^2 t^2}$$

$$x = \frac{p_0 c}{eE} \operatorname{Arsh} \frac{ceEt}{\mathcal{E}_0}$$

$$\mathcal{E} = \sqrt{m_0^2 c^2 + c^2 p_0^2 + c^2 e^2 E^2 t^2}$$

$$\mathcal{E}_0 = \mathcal{E}\Big|_{t=0}$$

$$y = \frac{\mathcal{E}_0}{eE}\sqrt{1 + \frac{c^2 e^2 E^2 t^2}{\mathcal{E}_0^2}}$$

$$\frac{xeE}{p_0 c} = \operatorname{Arsh} \frac{ceEt}{\mathcal{E}_0}$$

$$\operatorname{sh} \frac{xeE}{p_0 c} = \frac{ceEt}{\mathcal{E}_0}$$

$$y = \frac{\mathcal{E}_0}{eE}\sqrt{1 + \operatorname{sh}^2\left(\frac{xeE}{p_0 c}\right)}$$

$$\operatorname{ch} x = \frac{e^{x} + e^{-x}}{2}$$

$$\operatorname{sh} x = \frac{e^{x} - e^{-x}}{2}$$

$$\operatorname{ch}^2 x - \operatorname{sh}^2 x = \frac{1}{4}\left(e^{2x} + 2 + e^{-2x} - e^{2x} + 2 - e^{-2x}\right)$$

$$y = \frac{\mathcal{E}_0}{eE} \operatorname{ch} \frac{xeE}{p_0 c}$$

$$y = \frac{\mathcal{E}_0}{eE} \operatorname{ch} \frac{xeE}{p_0 c}$$ – цепная линия

$$v \ll c \mapsto p_0 = \frac{m_0 v}{\sqrt{1 - \frac{v^2}{c^2}}} = m_0 v$$

$$\mathcal{E}_0 = \frac{m_0 c^2}{\sqrt{1 - \frac{v^2}{c^2}}} = m_0 c^2$$

$$\operatorname{ch} \frac{xeE}{p_0 c} = \operatorname{ch} \frac{v}{c} \Big|_{v \ll c}$$

$$\operatorname{ch} \alpha = \frac{1}{2}\left(e^{\alpha} + e^{-\alpha}\right) = \frac{1}{2}\left(1 + \alpha + \frac{\alpha^2}{2} + 1 - \alpha + \frac{\alpha^2}{2}\right.$$

Разлагая ch $\frac{xeE}{p_0 c}$ по степеням

$$y = \frac{eE}{2m v_0^2} x^2 + const$$

— движение по параболе

Движение заряда в постоянном магнитном поле

заряд e

магнитное поле $\bar{H} = H\bar{k}$

$$\dot{\bar{p}} = \frac{e}{c}[\bar{v} \times \bar{H}]$$

$$\bar{p} = \frac{\mathcal{E}\bar{v}}{c^2}; \quad \mathcal{E} - \text{Const}$$

$$\frac{\mathcal{E}}{c^2}\frac{d\bar{v}}{dt} = \frac{e}{c}[\bar{v} \times \bar{H}]$$

$$\begin{cases} \dot{v}_x = \dfrac{ecH}{\mathcal{E}} v_y \\ \dot{v}_y = -\dfrac{ecH}{\mathcal{E}} v_x \\ \dot{v}_z = 0 \end{cases}$$

$$\begin{cases} \dot{v}_x = \omega v_y \\ \dot{v}_y = -\omega v_x \quad \Big| \; i \\ \dot{v}_z = 0 \end{cases}$$

$$\frac{d}{dt}\left(v_x + i v_y\right) = -i\omega\left(v_x + i v_y\right)$$

$$v_x + i v_y = A e^{-i\omega t}$$

$$A = v_0 e^{-i\alpha t}$$

$$v_x + i v_y = v_0 e^{-i(\omega t + \alpha)}$$

$$v_x = v_0 \cos(\omega t + \alpha)$$

$$v_y = -v_0 \sin(\omega t + \alpha)$$

$$v_0 = \sqrt{v_x^2 + v_y^2}$$

$$x = x_0 + \frac{v_0}{\omega} \sin(\omega t + \alpha)$$

$$y = y_0 + \frac{v_0}{\omega}(\cos \omega t + \alpha)$$

$$\frac{v_0}{\omega} = \frac{v_0 \mathcal{E}}{ecH} = \frac{pc}{eH} = r$$

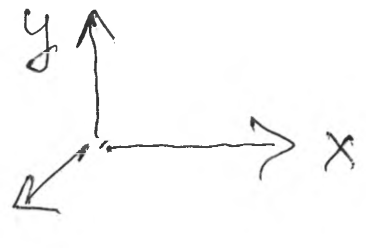
$$z = z_0 + v_0 t$$

$$v \ll c \longmapsto \mathcal{E} = m_0 c^2$$

$$\omega = \frac{eH}{m_0 c} \rightarrow \frac{eH}{mc}$$

Движение заряда в скрещенных полях

e - заряд



$\bar H \parallel oz$

$\bar E \parallel oy$

$v \ll c \mapsto \bar p = m_0 \bar v = m \bar v$

$$m\dot{\bar v} = e\bar E + \frac{e}{c}[\bar v \times \bar H]$$

$$m\ddot x = \frac{e}{c}\dot y H$$

$$m\ddot y = eE - \frac{e}{c}\dot x H \quad \Big| \, t$$

$$m\ddot v_z = 0 \mapsto z = \frac{eE_z}{2m}t^2 + v_{0z}t = v_{0z}t$$

$$\frac{d}{dt}(\dot x + i\dot y) + i\omega(\dot x + i\dot y) = i\frac{e}{m}E_y$$

$$\omega = \frac{eH}{mc}$$

$$\dot x + i\dot y = Ae^{-i\omega t} + \frac{eE}{H}$$

$$A = b e^{i\alpha} \mapsto A = b, \ \alpha = 0$$

$$\dot x = A\cos\omega t + \frac{cE}{H}$$

$$\dot y = -A\sin\omega t$$

$$\bar{v}_x = \frac{cE}{H}; \quad \bar{v}_y = 0$$

$$v \ll c; \quad \frac{H}{E} \gg 1; \quad \frac{E}{H} \ll 1$$

$$t = 0; \; x = 0; \; y = 0$$

$$x = \frac{A}{\omega} \sin \omega t + \frac{cE}{H} t$$

$$y = \frac{A}{\omega} (\cos \omega t - 1)$$