Pohyb náboje v magnetickém poli

$\vec{F} = q.\vec{E}$

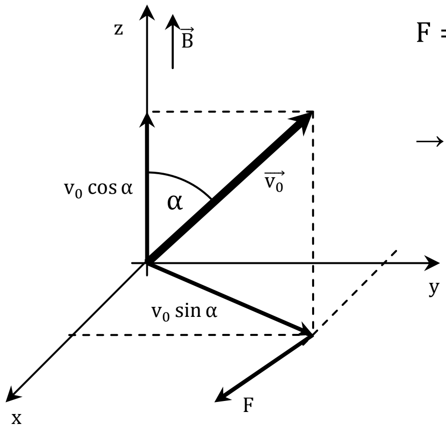
$\vec{F} = q.(\vec{v} \times \vec{B})$ – na náboj v klidu síla nepůsobí

$z \parallel \vec{B}$

$\vec{F} \perp \vec{B}$

$\vec{F} \perp \vec{v}$

$F \parallel xy$



$F = q.v.B.\sin\alpha$

→ výsledný pohyb je šroubovice

$z = v_0 \cos\alpha\,.\,t$

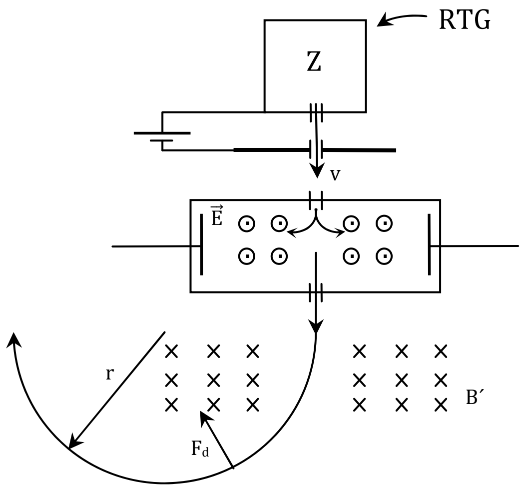
$q = v_0.\sin\alpha\,.\,B = \dfrac{(v_0 \sin\alpha)^2 m}{r}$

$r = \dfrac{m.v_0.\sin\alpha}{q.B}$ ⇒ náboj se pohybuje v rovině xy po kružnici

$\omega = \dfrac{2\pi}{T} = \dfrac{v}{r} = \dfrac{v_0 \sin\alpha}{\dfrac{m.v_0.\sin\alpha}{q.B}} = \dfrac{q.B}{m}$

$T = 2\pi.\dfrac{m}{q.B} \Rightarrow f = \dfrac{1}{T}$

Hmotnostní spektograf



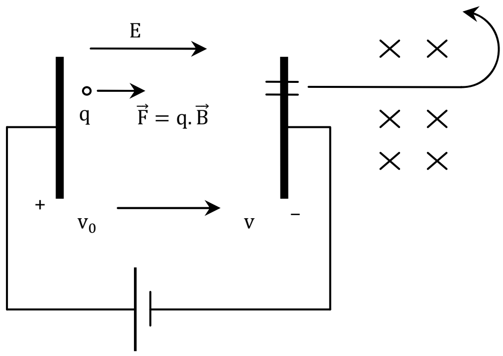
$qE = qvB$

$v = \dfrac{E}{B}$

$F_d = \dfrac{mv^2}{r} = qvB'$

$$\frac{m\frac{E}{B}}{r} = qB' \Rightarrow \frac{q.B.B'.r}{E} = m$$

Specifický náboj elektronu



$$W_p = e.U = \frac{1}{2}mv^2 \Rightarrow v = \sqrt{\frac{2eU}{m}}$$

$$W_p = \underbrace{-\int \vec{E}.\vec{dr}}_{U}.e$$

$$evB = \frac{mv^2}{r}$$

$$eB = \frac{m\sqrt{\frac{2eU}{m}}}{eB} = \frac{\sqrt{\frac{m^2 2eU}{me^2}}}{B} = \frac{\sqrt{\frac{m}{e}2U}}{B}$$

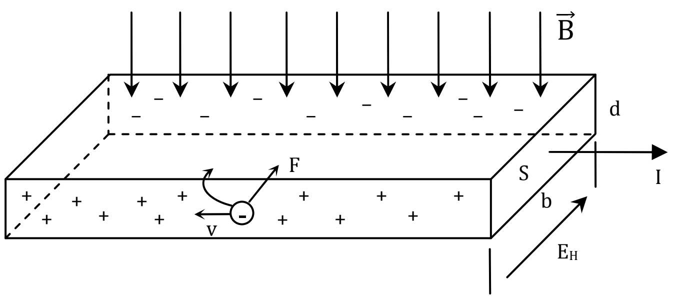
$$\frac{e}{m} = 1{,}759.10^{11}C.kg^{-1} \quad m_e = 9{,}11.10^{-31}kg$$

U[V]	v[ms^{-1}]	m_e
100	6.10^6	$9{,}12.10^{-31}$
1000 (keV)	2.10^7	$9{,}15.10^{-31}$
10^4	6.10^7	$9{,}30.10^{-31}$
10^5	$1{,}5.10^8$	$11{,}10.10^{-31}$
10^6 (MeV)	3.10^8	30.10^{-31}

$$eU = 1{,}602.10^{-19}.1V.C = \underbrace{1{,}602.10^{-19}}_{eV}\underbrace{VA}_{W}s\,[J]$$

$$1{,}602.10^{-19} = 1eV$$

Hallův jev



$$E_H.b = U_H \Rightarrow E_H = \frac{U_H}{b}$$

$F = q.\vec{v} \times \vec{B}$

$-evB = -eE_H \Rightarrow v = \frac{E_H}{B} = \frac{U_H}{B.d}$

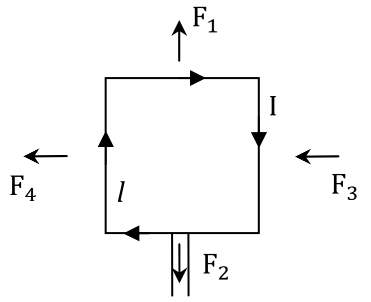
$\vec{j} = \rho.\vec{v}\ |.S$ $\rho = -ne$ – počet elektronů v m^3

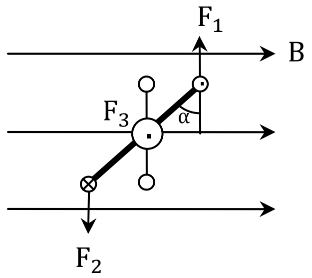
$j.S = I = \rho.v.b.d = \rho.b.d.\frac{U_H}{B.b} = -en.d.\frac{U_H}{B}$

$U_H = -\underbrace{\frac{1}{en}}_{R_H}.\frac{I.B}{d}$ R_H – hallova konstanta

$U_H = R_H.\frac{I.B}{d}$

Silové účinky na smyčku v magnetickém poli





$F = e.v.B$

$F = I.l.B$

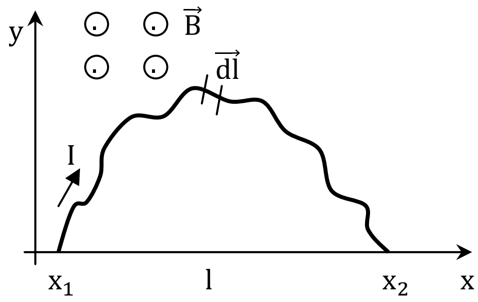
$I.S = \vec{m}$

$\vec{M} = \vec{l} \times \vec{F}$ mag. pole má snahu maximalizovat indukční tok Φ

$M = l.F.\sin\alpha = I.\underbrace{l^2.B}_{S.B=\Phi}.\sin\alpha = \vec{m} \times \vec{B} = \vec{M}$ → mag. moment smyčky

$\vec{p} \times \vec{E} = \vec{M}$ – el. pole

<u>Př.</u>



$F = I.\vec{l} \times \vec{B}$

$dF = I.\vec{dl} \times \vec{B}$

$I.\vec{dl} = I.dx\vec{i} + I.dy\vec{j} + 0\vec{k}$

$\vec{B} = B.\vec{k}$

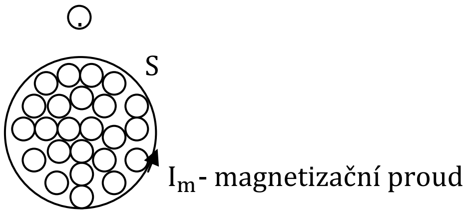
$$I.\vec{l} \times \vec{B} = \begin{vmatrix} \vec{i} & \vec{j} & \vec{k} \\ I.dx & I.dy & I.dz \\ 0 & 0 & B \end{vmatrix} = \vec{i}.I.dy.B - \vec{j}.I.dx.B + \vec{k}.0$$

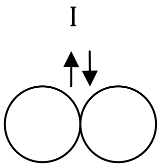
$dF = I.dy.B.\vec{i} - I.dx.B.\vec{j}$

$$\vec{F} = IB.\int_l (dy.\vec{i} - dx.\vec{j}) = IB.\int_0^0 dy - IB.\int_{x_1}^{x_2} dx = -I.B.l$$

Magnetická polarizace

elektrony kolem jádra – orbitální $\overrightarrow{m_0}$
elektrony kolem své osy – spin $\overrightarrow{m_s}$





$$\vec{J} = \lim_{\Delta V \to 0} \mu_0 . \frac{\sum \vec{m}}{\Delta V} = \mu_0 . \frac{\sum \vec{m}}{V} - \text{magnetická polarizace}$$

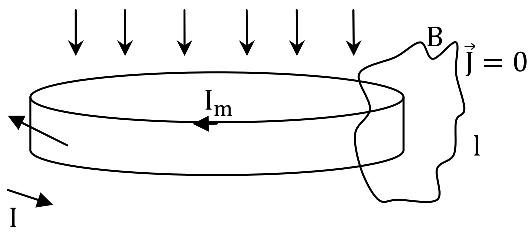
$$\vec{J} = \mu_0 . \frac{I_m . S}{V} = \mu_0 . \frac{I_m . S}{S . dl} \; [T]$$

$$I_m = \frac{1}{\mu_0} . \int_l \vec{J} . dl$$

$$\vec{M} = \frac{\vec{J}}{\mu_0} - \text{ vektor magnetizace } [A . m^{-1}]$$

$$I_m = \int_l \vec{M} . dl$$

$$I = \int_l \vec{H} . dl \quad \text{(ampérův zákon)}$$



$$\oint \vec{B} . \vec{dl} = \mu_0 (I + I_m)$$

$$I_m = \frac{1}{\mu_0} . \oint \vec{J} . \vec{dl}$$

$$\oint \vec{B} . \vec{dl} = \mu_0 I + \oint \vec{J} . \vec{dl}$$

$$\oint (\vec{B} - \vec{J}) . \vec{dl} = \mu_0 I \quad | . \frac{1}{\mu_0}$$

$$\oint \vec{H} . \vec{dl} = I$$

$$\oint \underbrace{\frac{\vec{B} - \vec{J}}{\mu_0}}_{\vec{H}} . \vec{dl} = I$$

$$\frac{\vec{B} - \vec{J}}{\mu_0} = \vec{H}$$

$\vec{B} = \mu_0 \vec{H} + \vec{J}$ $\quad$ $\vec{D} = \varepsilon_0 \vec{E} + \vec{p}$

$\vec{J} - \vec{B} - \mu_0 \vec{H} = \mu_0 \mu_r \vec{H} - \mu_0 \vec{H} = \mu_0 (\mu_r - 1) \vec{H} = \mu_0 \chi_m \vec{H}$ $\quad$ $\vec{p} = \varepsilon_0 \chi \vec{E}$

$\vec{J} = \mu_0 \chi_m \vec{H}$

→ magnetická susceptibilita