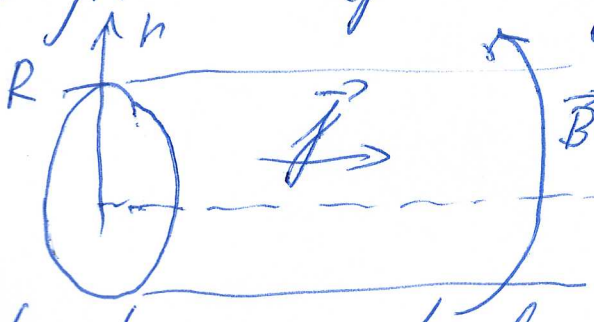
Current filament (pinch) - proudové vlákno



$I = \pi R^2 j$

constant current density j inside cylinder

Search for stationary state - hydromag. equilibrium

for $r \leq R$ $\quad B = \frac{\mu_0 j r}{2} = \frac{\mu_0 I r}{2\pi R^2}$

$r \geq R$ $\quad B = \frac{\mu_0 I}{2\pi r}$

Stationary equilibrium

$$\nabla p = \frac{\partial p}{\partial r} = \vec{j} \times \vec{B} = -\frac{\mu_0 I^2 r}{2\pi^2 R^4}$$

$$p = p_0 - \frac{\mu_0 I^2 r^2}{4\pi^2 R^4} \qquad p(R) = 0 \qquad p(r \geq R) = 0$$

$$p_0 = \frac{\mu_0 I^2}{4\pi^2 R^2} \Rightarrow p = \frac{\mu_0 I^2}{4\pi^2 R^2}\left(1 - \frac{r^2}{R^2}\right)$$

$$p + \frac{B^2}{2\mu_0} = \frac{\mu_0 I^2}{4\pi^2 R^2}\left(1 - \frac{r^2}{R^2}\right) + \frac{\mu_0 I^2}{8\pi^2 R^2}\frac{r^2}{R^2} = \frac{\mu_0 I^2}{4\pi^2 R^2}\left(1 - \frac{r^2}{2R^2}\right)$$

$$\frac{\partial}{\partial r}\left(p + \frac{B^2}{2\mu_0}\right) = -\frac{\mu_0 I^2 r}{4\pi^2 R^4} \neq 0$$

Bennet condition

$\hat{r}$: $\quad \frac{1}{\mu_0}\left[(\vec{B}\nabla)\vec{B}\right]_r = -\frac{B_\varphi^2}{\mu_0 r} = -\frac{\mu_0 I^2 r}{4\pi^2 R^4}$

$p = n_e k_B T_e + n_i k_B T_i = n_e k_B (T_e + T_i/Z)$

izotermální

N - number of electron per length

$$N = 2\pi \int_0^R n n_e \, dr = \frac{1}{k(T_e + T_i/Z)} \frac{\mu_0 I^2}{2\pi R^4} \int_0^R r(R^2 - r^2)\, dr$$

$$\Rightarrow I^2 = \frac{8\pi}{\mu_0} N k_B (T_e + T_i/Z) \qquad N = 2\times 10^7 N k_B (T_e + T_i/Z)$$