2007 Part II Q1 Exp.

$\beta_\alpha = \frac{P_\alpha}{B^2/2\mu_0} = \frac{n_\alpha T_\alpha}{B^2/2\mu_0}$ where n_α, T_α are the density and temperature of hot α's. $\Rightarrow T_\alpha = 3.5$ MeV

Simple drag / slowing-down equation for n_α

$\frac{dn_\alpha}{dt} = S - \frac{n_\alpha}{\tau_{se}}$ τ_{se} = slowing down time, for slowing on electrons

S = local production rate of α's per unit volume per unit time

$S = n_D n_T \langle\sigma v\rangle = \frac{P_{tot}}{Vol \cdot Q_{DT}}$ $Vol = 2\pi^2 R a^2$, $Q_{DT} = 17.6$ MeV

In steady state, $n_\alpha = S \cdot \tau_{se}$

From NRL, $\nu_{se} = n_e Z_\alpha^2 \ln\Lambda \cdot 1.6 \cdot 10^{-9} \left(\frac{m_\alpha}{m_p}\right)^{-1} T_e^{-3/2}$ T_e in eV

$\tau_{se} = \frac{1}{1.6 \cdot 10^{-9}} \frac{\frac{m_\alpha}{m_p} T_e^{3/2}}{n_e Z_\alpha^2 \ln\Lambda}$ n_e in cm^{-3}, $\ln\Lambda \approx 15$

$\beta_\alpha \approx \frac{\frac{P_{tot}}{Vol} \frac{T_\alpha}{Q_{DT}} \tau_{se}}{B^2/2\mu_0} \approx 0.02$ 2%