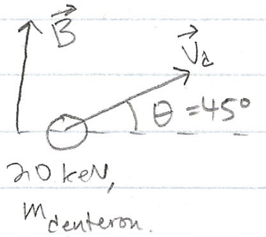
Week 3 Problems → Chen 2.10, 2.11, 2.19

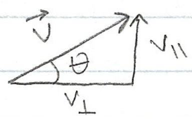
W+M have colloquia on Fridays from 4 to 5pm

Intro to Plasmas - Virtual Plasma Series)

Chen 2.10) A 20 keV deuteron in large mirror fusion device has a pitch angle $\theta = 45°$ @ the midplane, where $B = 0.7\,T$. Compute its Larmor radius.



We'll say that $\vec{B}$ points in the positive y direction. So our velocity components are:



. Now the Larmor radius is given as

$$r_L = \frac{m v_\perp}{|q| B}.$$

We need the speed → given from energy;

$E = 20$ keV, and this is the deuteron's kinetic energy; therefore

$$E = 20\text{ keV} = \frac{1}{2} m v^2, \quad \text{so} \quad v = \sqrt{\frac{2(20\text{ keV})}{m}}$$

The mass of the deuteron is $m_d = 1875\ MeV/c^2$, so that gives

$$v = \sqrt{\frac{2(20\times10^3\ eV)}{(1875\times10^6\ eV/c^2)}} = 0.0046\,c \Rightarrow v = 1.386\times10^6\ m/s$$

Now the perpendicular component is

$$v_\perp = v\cos\theta = 1.386\times10^6 \cos(45°) \rightarrow v_\perp = 9.8\times10^5\ m/s$$

The charge for a deuteron is $q = 1.602\times10^{-19}\ C$

we know $m_d = 1875\ MeV/c^2$ → in SI units; $m_d = 3.34\times10^{-27}\ kg$

So the Larmor radius is

$$r_L = \frac{m_d v_\perp}{|q| B} = \frac{(3.34\times10^{-27}\,kg)(9.8\times10^5\ m/s)}{(1.602\times10^{-19}\,C)(0.7\,T)}, \quad \text{and}$$

$$\boxed{r_L = 0.029\ m}$$