24.7: Magnetic Fields Exert Torques on Dipoles

Forces and Torque on a current loop in a uniform magnetic field.

Assume \vec{B} : uniform and to the right. A rectangular current loop is in the x-y plane. What happens? 4 (1) 3) Ly I \checkmark 2

Poll: what are the magnitude and direction of the force on wire segment 1?



T= I LxLy B area generalize: magnetic dipole moment $\vec{\mu} \equiv I \cdot (area), direction is$ perpendicular to the loop, parallel to the B That the loop tends to create. n II IZ = M B sin X B (due to other somes not shown.)

Result: the external field Berente a torque that tends to align it with The applied B. tends to align \propto l.g. В S \mathcal{N} 5 N je is a magnetic dipole. Just like a company S N it's north pole points medle, along magnetic field lines ENERGY × A higher energy m Ju Lower energy B B , Th Lowest energy Th B Highest energy 0 = 1800

Potential energy = U = - in · B = - in Bcoo Umin = -uB { difference = 2,uB Umax = + uB

atomic example:

M = MB = "Bohr magneton" = typical scale of atomic magnetic momenta. MB = 9.27 X10 -24 A.m2 apply B = 1.5 T (big lab magnet.) Energy anti-aligned = $\mu_B B =$ $U_{max} = (9.27 \times 10^{-24} A \cdot m^2)(1.5 T) = 1.39 \times 10^{-23} T$ Energy aligned = $-\mu_B B = -1.39 \times 10^{-23} J$ $\Delta U = 2.78 \times 10^{-23} J_{\chi} 1.602 \times 10^{-19} eV$

 $\Delta U = 0.00017 eV$ This is small but detectable - detecting such flips is at the heart of NMR/MRI techniques.

Atomic picture: (really cheating here !) NVC leus I = charger <u>e</u> <u>e</u> Time <u>T</u> attr/rr $\frac{I}{2\pi} = \frac{eN}{2\pi}$

Express in terms of angular momentum L=MNN I= e(1/mn) = eL 2TT 2TM22 M= I. area = I(TTN2) = eL 2m Quantum Mechanics: Don't really have clear cércular orbits, but we do have angular morention. $M_{B} = \frac{e^{\chi}}{2me} = \frac{(1.602\chi_{10}^{-19}C)(1.05\chi_{10}^{-34}kgm^{2}/s)}{2(9.11\chi_{10}^{-31}kg)}$ MB = 9-27 X10 - 24 A.m2.

24.8: Magnets and Magnetic Materials

A rich and complex field. Focus on one application: Ferromagnetism. In some materials, the material has a permanent magnetic dipole moment. (Well, not permanent, but persistent under normal room temperature pressures and conditions.). These dipole moments tend to align with an applied magnetic field, and *also* produce their own magnetic field.

Disordent The atomic magnetic moments due to unpaired electrons point in random directions. The sample has no net magnetic moment. field of ternal magnetic Hpp an N 5 magnetic moment will tond to dign.



N

S



Magnetic domains	Magnetic moment of a domain The atomic moments are lined up within
	each domain.
The magneti	c moments of the
domains tend The sample :	I to cancel one another. is a whole possesses
expiriment focusio, inc.	etic moment.

Unmagnetized piece of iron		
1. Initially, the magnetic moments of the domains cancel each other; there is no net magnetic moment.		
2. The magnetic field from a magnet causes favorably oriented domains (shown in green) to grow at the expense of other domains.		
3. The resulting domain structure has a net magnetic moment that is attracted to the magnet. The piece of iron has		
been magnetized. © 2019 Pearson Education, Inc. The applied magnetic for	Il in duces manet	
dipoles that align so as to yield an		
alla chive price		