Problem Set 1 - Magnetism & Spintronics ELEG/PHYS667

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Due: Monday, Feb 27, 2006 in class

1. In my lab I have a spectrometer with 0.25m pathlength. It has a diffraction grating with 600 lines/mm.
   (a) If I put a sodium fluorescent lamp in a 1T=10^4gauss field, what is the difference in wavelength for a split line around 550nm?
   (b) The elements in my CCD detector on the spectrometer are $25\mu m$ apart. This serves as an effective detection aperture. How far apart can I expect the split lines to be separated at the detector, and can I see the Zeeman effect with this equipment and field?
2. The Stern-Gerlach experiment was the first experimental confirmation of space quantization due to the existence of spin. In the original experiment with thermal silver atoms (1000K), the inhomogenous magnetic field was created by a magnet 3.5 cm long with a field gradient of 10 T / cm.
   (a) Using the dipole interaction energy $U = -\mu \cdot B$, find the deflection force on a silver atom with magnetic dipole μ_B as a function of the field gradient.
   (b) If the velocity of the thermal silver atoms is given by
   $\frac{M}{2}v^2 = \frac{3}{2}k_BT$,
   what is the transverse deflection distance over the length of the magnet? Compare this to the photograph of the original split pattern at http://www.physicstoday.org/vol-56/iss-12/captions/p53cap4.html
3. Wolfgang Pauli originally rejected the idea of spin because of its physical interpretation as arising from mechanical motion.
   (a) Suppose the electron were not a point particle but a sphere. By equating the rest mass energy of the electron (m_ec^2=511 keV) with the electrostatic energy of a charged sphere with total charge e, derive the semiclassical electron radius.
   (b) How fast would this "electron sphere" have to spin to give a magnetic moment on the scale of μ_B? Does this make sense? Why?