Due: Thursday, 02/17

7. In this problem, we look at two properties of the static electric and magnetic fields that are important for trapping charged particles and paramagnetic atoms (or molecules), respectively.

a) Explain why it is impossible to construct a purely electrostatic trap to hold a charged particle in free space.

b) The states of paramagnetic atoms (molecules) can be classified into *low-field-seeking* and *high-field-seeking* states. Propose a simple magnetic-coil geometry for trapping low-field seekers, and explain why it is impossible to do the same for high-filed seekers.

Hint: for the final part, an analogy of magnetic field with Coulomb or gravitational field may be useful. In particular, the fact that, for empty space, the field in the center of a sphere is the average of the field over the volume or the surface of the sphere could be helpful.

8. Consider Zeeman and Stark effects in atomic states with J=1/2 and J=1 (assume that nuclear angular momentum is zero). a) Draw schematic diagrams showing splitting of the Zeeman components. Write out expressions for relevant energy intervals. Estimate values of these splittings (in MHz) with an easily achievable magnetic field of 1 kG. b) Same for the Stark effect (you may want to look up derivation of the Stark effect formulae in a quantum mechanics book). Make numerical estimates for an atomic ground state in which electric polarizability is determined by interaction with an opposite parity state separated from it by a typical atomic energy interval; use electric field with strength 10^5 V/cm.

9. Give a plausibility argument to explain why there can exist stable negative multiply-charged ions with a positive nucleus of charge Z and an electron cloud of charge $-(Z+K)$, $K>1$.