Homework13

Problem 1 Paramagnetic susceptibility of liquid oxygen

How large is the magnetic moment of $1\ \mathrm{g}$ of liquid oxygen in a field of $1.8\ \mathrm{tesla}$, according to the data in Table in Lec 21-1? Given that the density of liquid oxygen is $850\ \mathrm{kg/m^3}$ at $90\ \mathrm{K}$, what is its paramagnetic susceptibility χ_m?

Problem 2 Earth dipole

At the north magnetic pole the earth's magnetic field is vertical and has a strength of $0.62 \times 10^{-5}\ \mathrm{tesla}$. The earth's field at the surface and further out is approximately that of a central dipole.

(a) What is the magnitude of the dipole moment in $\mathrm{joules/tesla}$?

(b) Imagine that the source of the field is a current ring on the "equator" of the earth's metallic core, which has a radius of $3000\ \mathrm{km}$, about half the earth's radius. How large would the current have to be?

Problem 3 Rotating a bacterium

In magnetite, Fe_3O_4, the saturation magnetization M_0 is $4.8 \cdot 10^5\ \mathrm{joule/(tesla \cdot m^3)}$. The magnetic bacteria discovered in 1975 by R. P. Blakemore contain crystals of magnetite, approximately cubical, of dimension $5 \cdot 10^{-8}\ \mathrm{m}$. A bacterium, itself about $10^{-6}\ \mathrm{m}$ in size, may contain from 10 to 20 such crystals strung out as a chain. This magnet keeps the whole cell aligned with the earth's magnetic field, and thus controls the direction in which the bacterium swims; see Blakemore and Frankel (1981). Calculate the energy involved in rotating a cell containing such a magnet through 90° in the earth's field (assuming initial alignment), and compare it with the energy of thermal agitation, $k_{\mathrm{B}}T$.