ELEG 667–016; MSEG-667-016 - Solid State Nanoelectronics – Fall 2005
Solutions
Homework #5 - due Tuesday, 17 October 2005, in class

1.
The maximum demagnetization field in a Néel wall is $-4\,\pi M_s$, (in cgs units) and the maximum self-energy density is $\frac{1}{2}(4\pi M_s)M_s$. In a wall of thickness Na, where ***a*** is the lattice constant, the demagnetization contribution to the surface energy is $\sigma_{demag} \approx 2\pi M_s{}^2 Na$. This is a type of anisotropy energy. The total wall energy, exchange + demag, is $\sigma_w \approx \left(\pi^2 JS^2/Na^2\right) + \left(2\pi M_s{}^2 Na\right)$, by use of ($\sigma_w = \sigma_{ex} + \sigma_{anis}$). The minimum is at

$$\partial\sigma_w/\partial N = 0 = -\pi^2 JS^2/N^2a^2 + 2\pi M_s{}^2 a\text{, or}$$
$$N = \left(\frac{1}{2}\pi JS^2/M_s{}^2a^3\right)^{1/2},$$

and is given by

$$\sigma_w \approx \pi M_s S(2\pi J/a)^{1/2} \approx (10)(10^3)\left(10^{-4}/10^{-8}\right)^{1/2} \approx 10\ \text{erg/cm}^2,$$

which is larger than (1 erg/cm^2) for iron. (According to Table 8.1 of the book by R. M. White and T. H. Geballe, the Bloch wall thickness in Permalloy (20% iron and 80% nickel) is 16 times that in iron; this large value of δ favors the changeover to Néel walls in thin films.)

2. $$\begin{aligned} M_A T &= C\left(B - \mu M_B - \varepsilon M_A\right)\ \ (B = \text{applied field}) \\ M_B T &= C\left(B - \varepsilon M_B - \mu M_A\right) \end{aligned}$$

Non-trivial solution for B = 0 if

$$\begin{vmatrix} T+\varepsilon C & \mu C \\ \mu C & T+\varepsilon C \end{vmatrix} = 0;\ T_C = C(\mu - \varepsilon)$$

Now find $\chi = (M_A + M_B)/B$ at $T > T_C$:

$$MT = 2CH - CM(\varepsilon + \mu);\ \chi = \frac{2C}{T + C(\mu + \varepsilon)}$$
$$\therefore \theta/T_C = (\mu + \varepsilon)/(\mu - \varepsilon)\ .$$