STATISTICAL PHYSICS COMPUTER LAB #2a
MAGNETIC COOLING

Magnetic cooling is used to lower temperatures below about 1K. The system used is a paramagnetic salt such as $Cr(NO_3)_3*9H_2O$ or $FeNH_4(SO_4)_2*12H_2O$ in which the magnetic ions (Fe^{3+}) are separated by many other atoms and thus interact very weakly. For simplicity we will assume the spin to be 1/2, so we can describe this system of spins in a magnetic field as a two-state model. For simplicity will use a system of units with $k_B := 1$ and $g\mu_B := 1$. Will start from the free energy per spin

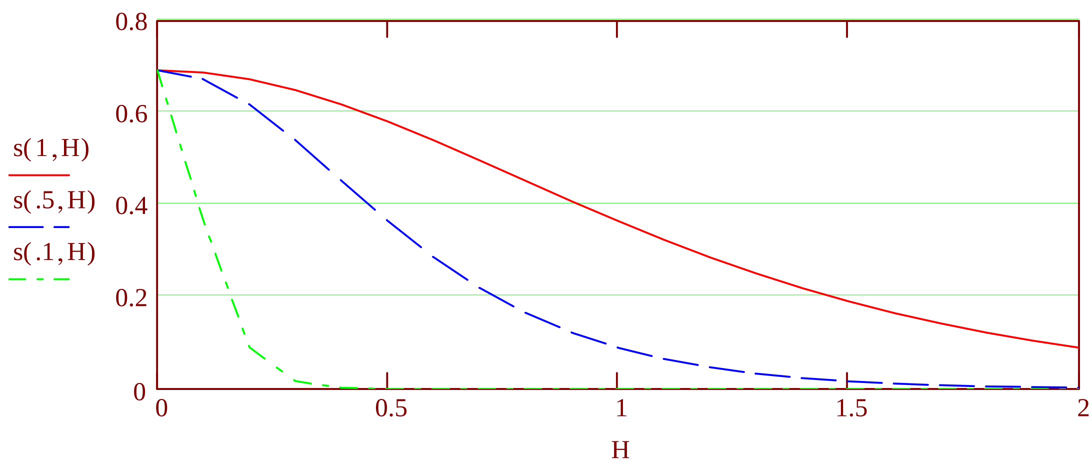
$$f(T,H) := -k_B \cdot T \cdot \ln\left(2\cdot\cosh\left(\frac{g\mu_B}{k_B}\cdot\frac{H}{T}\right)\right)$$

. Then we calculate the entropy by using

$s = -df/dT$.
$$s(T,H) := k_B \cdot \ln\left(2\cdot\cosh\left(\frac{g\mu_B}{k_B}\cdot\frac{H}{T}\right)\right) - k_B \cdot \tanh\left(\frac{g\mu_B}{k_B}\cdot\frac{H}{T}\right)\cdot\frac{g\mu_B}{k_B}\cdot\frac{H}{T}$$

Note that an adiabat, i.e. constant s, corresponds to H/T = constant.
The magnetic cooling proceeds in two steps: (i) start with the system in contact with a Helium bath (fixed T) and increase the magnetic field. By doing this the spins get alligned thus the disorder and s are reduced. (ii) Decrease fast the magnetic field. This process is adiabatic. Since H/T = constant and since we diminish H then T is reduced.

$H := 0, .1 .. 2$



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