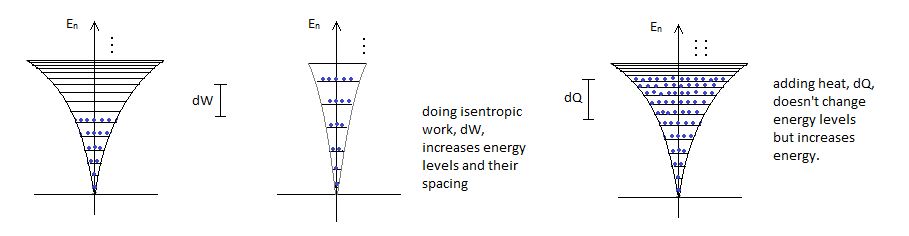
**Pictoral Representation of Stuff**

It’s useful to have a way to visualize S and E and X, etc., with an energy diagram, so I guess I’ll do that. I’ll leave out N and ψ dependence. Or rather, I’ll leave out N dependence, and subsume ψ dependence into X dependence. So we can say that the system has some energy levels. The position of the energy levels is governed by X (i.e., volume, field strength, whatever). These energy levels will usually be increasingly degenerate with increasing energy, often by some power, but for something like a single spin system, they’d each have degeneracy of 1 (even though single spin system is probably of dubious applicability to stat mech). I’ve made the length of the line proportional to the degeneracy in some sense.



So in some time interval (t, t + τ), the system will meander through various states of the system, within some energy window ΔE. Technically all energies are possible thanks to the exponential distribution e-βE, but for visualization purposes we’ll say there’s an effective cutoff at E ~ 1/β = kT. And we may represent it as a sort of histogram – number of dots representing something like the number of times the system lands on a microstate in that energy level. This roughly proportional to the number of microstates in that level. But how can we say a large system has any probability of being in its ground state at some finite temperature? Well it does, but super-small, at least for a large N system, and so negligible. For small system, perhaps we can chalk it up to uncertainty in being able to precisely nail down the amount of energy transferred from one system to the other when in thermal contact? Hmmm.

Anyway. The average energy, E, is basically, well, the average energy as governed by that histogram. As a statistical quantity, the energy will self-average for large systems as the degeneracy of higher energy levels grows so fast that histogram is dominated by just a few closely spaced levels near the top usually. Can see average E goes up if do work, which spreads the energy levels apart w/o changing their population, and also if we add heat which makes higher levels more populer.

Then the entropy S(E,X) is basically the <Σnpnln(pn)> of the histogram, where pn is probability of occupation of the levels. Remember this is largest for a uniform distribution pn = const. Can see that since work doesn’t change distribution, it doesn’t change entropy. But adding heat does spread population out – make it more uniform – and so more entropic.

Can interpret T as spread of histogram. Can then see that doing work increases T because it spreads energy levels apart. And adding heat does too obviously. Can also reason via T = dE/dS (evaluating at the average energy – usually pretty close to the top energy level occupied). If do work, then since energy levels are spread further apart, it will cost a lot more energy to get to the next level, and thereby increase S, than it did before. And so T has gone up. If add heat, adding a bit of energy will do much less to make the distribution more uniform if E is already large, than if its small. And so entropy will increase much less if E is already large. And so dE/dS will be larger, hence T as well.