

PREDICTING HEAT CAPACITY

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Reference: Daniel V. Schroeder, *An Introduction to Thermal Physics*, (Addison-Wesley, 2000) - Problem 3.8.

If we know the energy U of a system as a function of temperature, we can predict its heat capacity at constant volume using

$$(1) \quad C_V = \left(\frac{\partial U}{\partial T} \right)_{N,V}$$

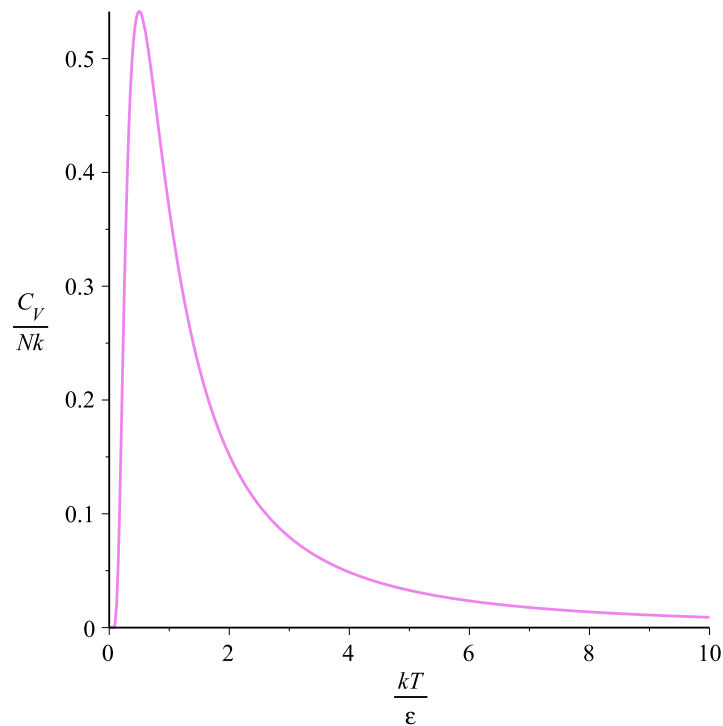
For an Einstein solid at low temperature, we have

$$(2) \quad U = N\epsilon e^{-\epsilon/kT}$$

where ϵ is the magnitude of one energy quantum. The heat capacity is therefore

$$(3) \quad C_V = \frac{N\epsilon^2}{kT^2} e^{-\epsilon/kT}$$

We can plot C_V/Nk versus kT/ϵ to see the shape of the curve:



The Einstein solid has a peak in its heat capacity at a very low temperature of $T = \epsilon/2k$ (differentiate C_V with respect to T and set to zero). However, as Schroeder points out, this isn't the observed heat capacity of real solids at low temperatures.

This method of predicting heat capacity relies on being able to find $U(T)$, which so far we've been able to do only by finding an expression for the multiplicity of states Ω in terms of the energy U (and other parameters), then using that to find the entropy $S = k \ln \Omega$, then finding $U(T)$ from the expression $1/T = \partial S / \partial U$. In most cases, finding an expression for the multiplicity of states is not possible, so we need another method of getting $U(T)$ which we'll hopefully get to eventually.

PINGBACKS

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