Lecture 12

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1 Ideal Gas (Cont'd)

We derived the approximation

$$S(U,N,V) = kN\left(\ln\left[\frac{V}{N}\left(\frac{4\pi mU}{3Nh^2}\right)^{1.5}\right] + \frac{5}{2}\right)$$

And differentiating for temperature gives

$$U = \frac{3}{2}kNT$$

This is a simplification, as this gives negative entropy at T when we fix density $\frac{V}{N}$. Therefore, the ideal gas law does not hold if it is too cold.

1.1 De Broglie Wavelength

$$\lambda = \frac{h}{p}$$

We define a **thermal de Broglie Wavelength** by

$$\lambda_{\text{th}} \propto \frac{h}{\sqrt{mkT}}$$

Then

$$S = kN\left[\ln\frac{\bar{l}^3}{\lambda_{\text{th}}^3} + C\right]$$

where C is a constant, and $\bar{l}$ is the average distance between particles. Essentially, we can assume the model to be classical if the particles are not within each other's de Broglie wavelength.