Study about the conductivity equation

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We have the conductivity equation derived in class

$$\sigma = \sigma_0 e^{\frac{-\Delta}{kT}}$$

Taking a derivative of that with respect to temperature

$$\frac{d\sigma}{dT} = \sigma_0 e^{\frac{-\Delta}{kT}} \frac{\Delta}{kT^2}$$

Means the function will be at it's extrema at T $\rightarrow$ 0 or T $\rightarrow \infty$ (T$\neq$0 as it will violate the third law of thermodynamics) Taking the second derivative to check for inflection points

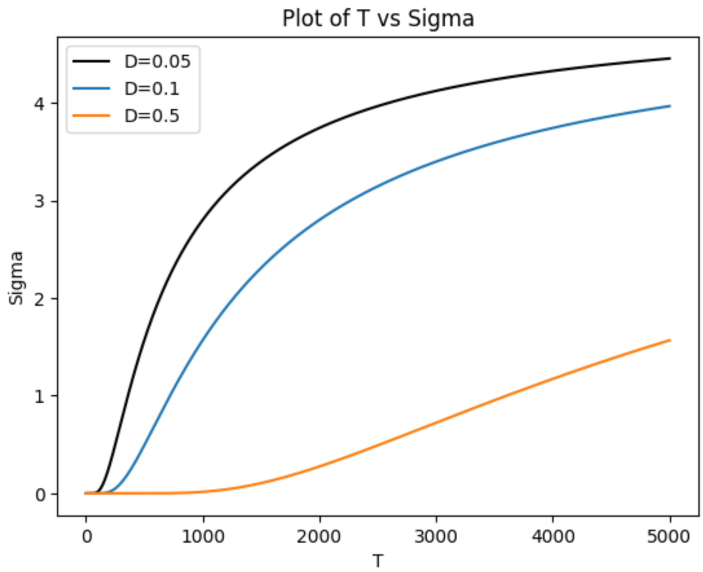
$$\frac{d^2\sigma}{dT^2} = \sigma_0 \frac{\Delta^2}{k^2T^4} e^{\frac{-\Delta}{kT}} - 2\sigma_0 e^{\frac{-\Delta}{kT}} \frac{\Delta}{kT^3}$$

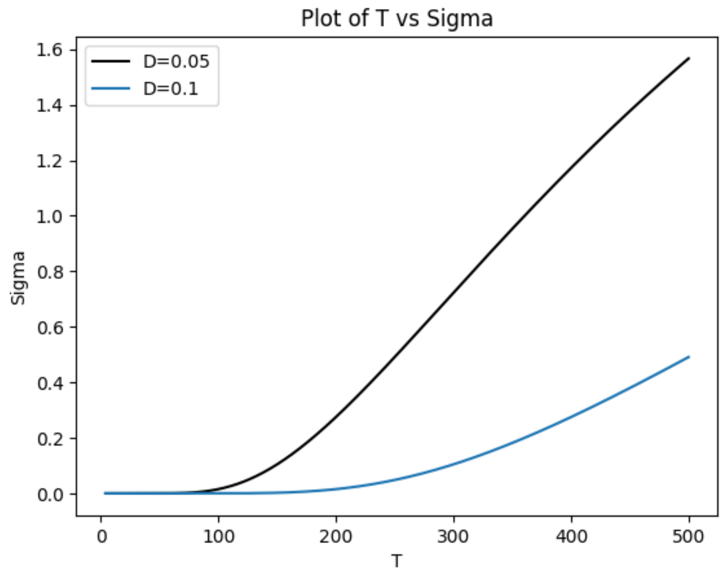
Finding the inflection points

$$\sigma_0 \frac{\Delta^2}{k^2T^4} e^{\frac{-\Delta}{kT}} = 2\sigma_0 e^{\frac{-\Delta}{kT}} \frac{\Delta}{kT^3}$$

$$\frac{\Delta}{2kT} = 1 \text{ or } T = \frac{\Delta}{2k}$$

But as the function is a monotonically increasing function, this should increase, stop and still increase but at a slower rate. But if we try to find the order of inflection point, taking Δ to be around 0.05-0.5 eV, meaning T should be around $(0.29 - 2.9) \times 10^3 K$.





Graphs for reference (Taking σ_0=1 for ease), note that due to resolution, the graph appears to be touching 0, but it starts from 4K, the temperature of liquid Helium.