VAPOREQUILIBRIUMFOR AHELIUM FILM(MKS)

Start with the saturated vapor pressure of liquid helium, reduce it to an unsaturated vapor within the van der Waalsspotential at a height \( h \), then find the film thickness in a box with a fixed number of atoms.

Saturated vapor pressure from a fit to table...

\[ P_s(T) := \exp\left[\frac{4.24846}{1 + \frac{.524764}{T}} + 11.8971 - 7.80921\left(\frac{1}{T} + .524764\right)\right] \text{ (Kelvin, Pascals)} \]

Pressure in equilibrium with a film, thickness \( h \) is reduced by the Boltzmann factor...

\[ P(T, h) := P_s(T) \cdot \exp\left[\frac{T_v}{T} \left(\frac{h_1}{h}\right)^3 \left(\frac{1}{1 + \frac{h}{h_r}}\right)\right] \]

This relates the three quantities, \( P \), \( T \), and \( h \), so any two determine the third. The area and volume of the container determine where the helium is at any temperature. Ideal gas behavior is assumed in the vapor.

Area \( A := 10 \) Volume \( V := 10 \cdot 10^{-6} \) \( T = 0 \) thickness \( h_0 := 2.5 \cdot 10^{-9} \)

constant number of particles \[ \frac{P(T, h) \cdot V}{k \cdot T} + \frac{h \cdot A}{h_1^3} = \frac{h_0 \cdot A}{h_1^3} \]

This can be solved numerically for the thickness to show how the film evaporates as temperature is raised...

\[ x := 0.9 \cdot \frac{h_0}{h_1} \quad \text{vok} := \frac{V \cdot h_1^3}{k \cdot h_0 \cdot A} \quad H(T) := h_0 \cdot \text{root}\left\{\frac{P(T, x \cdot h_0)}{T} \cdot \text{vok} + x - 1, x\right\} \]

\( T := 0.30, 0.35, 1.7 \)
Note that, for our third sound chamber containing a surface reservoir, the evaporative thinning turns on well above 0.5 K.