Physics 114 Statistical Mechanics Spring 2021

Week 7 Reading and Problem Assignment

Overview:

This is meant to be a light week for reading and problems, given our Swat (mini) Spring Break. It will also be a change of pace from what we've been doing. So far, we have studied thermodynamics; then found that stat mech forms the basis for key thermodynamic ideas. This week, we do *kinetic theory of gasses.* We meet an old topic: pressure, and some new ones which are *transport properties*. We'll study *viscosity*, *thermal conductivity* and *diffusion constant*. They describe how momentum, heat, and matter move, given the existence of a gradient. They are relevant beyond gasses ... applying to liquids (and for thermal conductivity, to solids as well). But, by doing "kinetic theory", we are centering our learning on gas molecules flying around kinetically. Fundamentals like their mass, size, and temperature (hence, typical velocity) allow us to predict their transport properties.

Suggested Reading:

B&B Chapters

- 6
- 7 (skip example 7.7)
- 8
- 9 (skip section 9.4)

There are no Warmup Problems this week

Problems to discuss in our meeting

Note: The * means that these problems are to be handed in. They are due the day after we meet. However, extensions to Friday will be liberally granted :-)

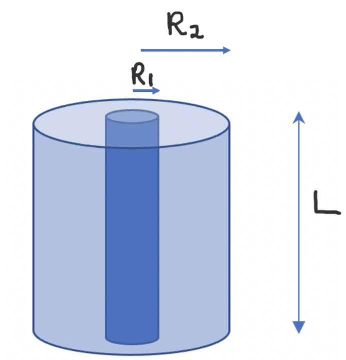
1*: Molecules hitting a surface: B&B 6.5

2 : Deposition and Effusion of molecules
i) B&B Problem 7.1
ii)B&B Problem 7.2

3*: Mean scattering time & mean free path in astrophysics:
B&B Problem 8.4

4*: Viscosity, Thermal conductivity, and Diffusion:
Consider xenon gas at T = $298K$ and atmospheric pressure.

a) Please look up any additional constants related to the mass and size of a xenon atom, in order to use kinetic theory to calculate its viscosity η, thermal conductivity κ, and diffusion constant D.



b) Suppose we confine the xenon gas to the space between two coaxial cylinders (picture above) of length $L = 2.00\ m$. They have radii $R_2 = 0.650\ m$ and $R_1 = 0.150\ m$. Suppose the outer cylinder is rotated at a constant angular velocity of $0.300\ rad/sec$. We wish to hold the inner cylinder perfectly stationary against the viscous drag of the gas. How big a torque is required?

c) Suppose we do a different experiment with these cylinders and the confined xenon. We heat the inner cylinder so that it steadily absorbs a power of $75.0\ mW$. Suppose the outer cylinder is held at a constant temperature of $T_2 = 298K$. Assuming that κ is as you calculated in part a), what is the steady-state temperature T_1 of the inner cylinder? As a reality check ... was using that value of κ a decent assumption?