

**Homework 13 Advanced Thermodynamics**  
**Due Wednesday November 27, 2024**

Kojima S *110<sup>th</sup> Anniversary of Brillouin Scattering: Impact on Materials Science* Materials 15 3518 (2022) briefly summarizes Brillouin scattering for materials.

- a) Figure 2 shows the raw data obtained from an interferometer that displays Brillouin scattering. Explain what the Rayleigh, Stokes, and anti-Stokes lines are. Why are there no transverse peaks in this spectrum? Why are there three duplicate spectra shown (you will need to describe an interferometer to explain this)?
- b) Equation 2 gives a differential expression for the contrast in Brillouin scattering. The equation looks similar to an expression for  $(dH/dT)_S$  and  $(dH/dT)_P$ . Explain the relationship.
- c) Figure 3 superimposes Brillouin and Raman spectra for an oxide crystal. What is the difference in the measurement technique for Raman and Brillouin scattering? What is the difference between Raman and Brillouin scattering? How can the phonon density of states be obtained from these spectra?
- d) Equation 4 gives the relationship between the Brillouin frequency and the velocity of sound. Derive this equation (use the definition of the scattering vector  $s$  in this derivation). Equation 5 describes the attenuation of sound in the material. Explain the reasoning behind this equation.
- e) Figure 16 shows the dependence of the Brillouin frequency shift and the full width at half maximum for the peaks as a function of temperature for an organic drug that forms a glass or a crystal at low temperatures. Why do the FWHM curves differ for the glass and crystal? Why is the glass shift smaller than the crystal? (Crystallization is difficult and slow for many organic drugs so it is possible to have a stable supercooled liquid below the melting point.)