Quiz 11 Polymer Properties
April 19, 2019

Dynamic light scattering was developed due to 1) the development of the laser and 2) the understanding of Brownian motion as popularized by Einstein.

a) What properties of the laser made dynamic light scattering possible? Describe each and why it is important to DLS. (I have 4 properties.)

b) Macroscopic features of fluids, particularly the viscosity, were considered constitutive parameters before Einstein's time, that is there was no understanding involved, you kick the dog and it barks. You don't need to know it is a dog (until it bites you). The field of continuum mechanics is a field that relies on constitutive parameters to describe, with no understanding, the mechanical and rheological behavior of materials using tensors. To learn continuum mechanics, it is vital to realize at the start that the field involves no understanding at all. It is only descriptive and predictive, if I kick the dog twice it will bark twice; what is a dog? (I have no idea.) One can spend many frustrating hours trying to "understand" continuum mechanics (and pet management) and the related field of rheology. Give a description of the shear viscosity using tensors (like a vector but with two directions) and a sketch of laminar flow. Is laminar flow possible for a polymer?

c) 3kT/2 reflects the kinetic energy associated with thermal motion of a molecule. This energy is dissipated through the drag coefficient as described by Stokes Law, which relies on the bulk constitutive parameter shear viscosity (a.k.a. *the Fluctuation Dissipation Theorem*). First, is the tensor description given in part b possible for a molecule? Second, explain how a continuum mechanics parameter like viscosity, which relies on a continuum (meaning no understanding) at least by name, could be related to motion of molecules in the Stokes-Einstein equation. (*The Stokes-Einstein equation is the basis for most of our understanding of dynamics so you should be careful with your answer.*)

d) This week we also discussed the blob model. The blob model was experimentally verified in 1978 by Farnoux in a paper with authors that compromise a who's who of polymer physics in the 1970-1990's (Farnoux B, Boué F, Cotton JP, Daoud M, Jannik G, Nierlich M, De Gennes PG *Cross-over in Polymer Solutions*, Le Journal De Physique 39 77 (1978)). The experimental data in this paper is presented in Figure 2 and Figure 7 in a modified Zimm and a Zimm plot, $1/I$ vs q^{df}. For the blob models we are expecting positive or negative deviations from the Flory-Krigbaum (FK) or Flory (F) mass-fractal scaling laws. Figure 2 shows a positive deviation from FK scaling at low-q, while Figure 7 displays a negative deviation from F scaling at low-q. Verify that these deviations are appropriate.

e) Use a shareware like *GraphClick*® to digitize the two plots. Then replot the curves as log I versus log q which brings out power-laws and power-law transitions with no ambiguity. Identify power-law regimes and comment on experimental evidence presented in this paper for the existence of a "cross-over" q^* for these data.

a) Collimated, monochromatic, coherent, high flux.