Suspensions and polymer solutions

Exercise 8

25 May 2011

1. Show that the Flory-Huggins theory predicts the following power law for the difference between the spinodal concentrations as $\chi \to \chi_c^+$:

$$\phi_{\text{spin2}} - \phi_{\text{spin1}} \sim (\chi - \chi_c)^\beta, \quad \beta = 1/2.$$

Remark: This value of β is incorrect. The correct value is $\beta \simeq 0.3$.

2. Osmotic pressure of a semi-dilute polymer solution

   (a) i. Using the Flory-Huggins theory, calculate the osmotic pressure of a dilute or semi-dilute polymer solution to 2nd order in $\phi \ll 1$.

   ii. Show that the 1st-order term satisfies van't Hoff's law, i.e., that the pressure is $k_B T$ per molecular volume in a dilute solution.

   iii. At what volume fraction will the 2nd-order term dominate? Is that value smaller or larger than the overlap volume fraction ϕ^*? Does this result make sense?

   iv. What, therefore, is the Flory-Huggins prediction for the pressure of a semi-dilute solution ($\phi > \phi^*$)?

   (b) Find the osmotic pressure of a semi-dilute polymer solution in a good solvent using scaling arguments. (Hint: Apply the van't Hoff law again, the blobs serving now as effective particles.) Compare to the result of (a). Is the dependence on ϕ stronger or weaker? Why?