030502 Quiz 5 Polymer Properties

1) In class we used the analogy of the edge of a forest/jungle at sunset to describe screening.
a) Use this analogy to describe the screening length.
b) Use this analogy to describe a mean field.
c) For a mathematical random walk there is no excluded volume at all. Describe the conditions in the forest/jungle for a mathematical random walk.
e) What is the difference between a mathematical random walk and a random walk due to screening such as in a polymer melt?
d) For a polymer solution the direction from one persistence unit to another is of importance rather than the global direction to sunset. Develop a more elaborate model for screening where each tree in the forest glows like a fluorescent bulb. Describe the screening length and mean field for this model.

2) The following graph from Farnoux (as reported in Strobl) was used to support a blob model.

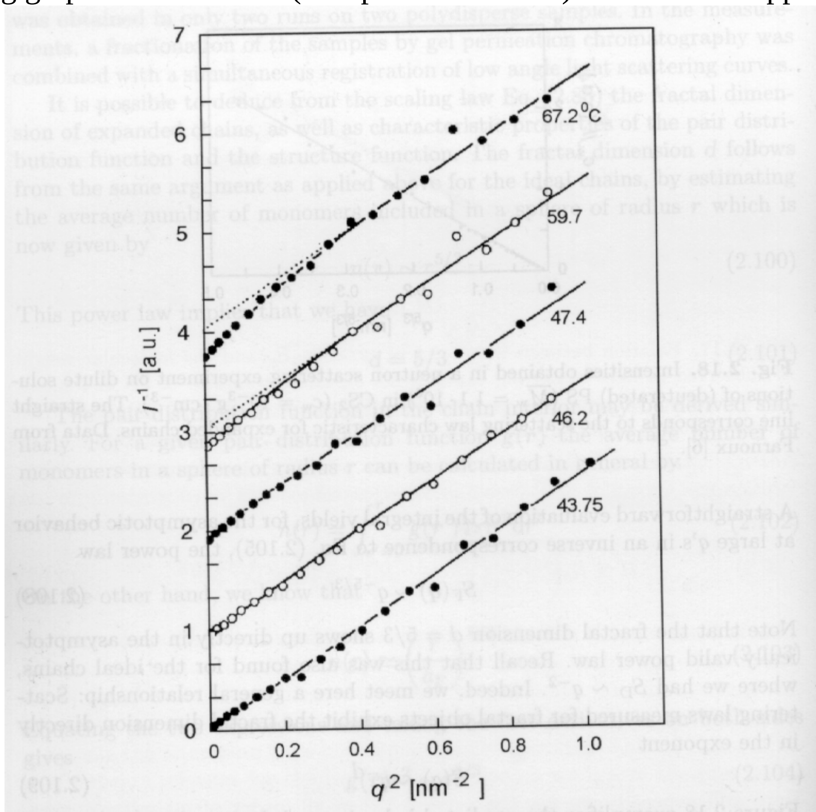


Fig. 2.19. Neutron scattering intensities $I(q)$ measured for dilute solutions of PS in cyclohexane ($\bar{M}_w = 3.8 \cdot 10^6; qR \gg 1$) at the indicated temperatures above the theta-point ($T = 35\,°C$). The straight lines correspond to the scattering law of ideal chains (subsequent curves are shifted upwards by constant amounts). Data from Farnoux et al. [7]

a) If a plot of 1/I versus q^2 is linear what dimension is the coil?

b) Explain a deviation from this at low-q towards a -5/3 power-law in terms of a blob model. (Which type of blob does this correspond with?)

c) If a very high temperature were accessible for this system what power-law would you expect?

d) Sketch this effect (67.2°C) in a plot of log(I) versus log(q)

e) Consider Farnoux's 1/I versus q^2 plot relative to your plot. Is Farnoux's data consistent with your sketch? (Extrapolate your -2 power-law and convert I to 1/I. Explain.)

3) Give scaling expressions for the following parameters from blob models:

a) Size of a thermal blob in terms of the persistence length and interaction parameter.

b) c* in terms of the number of persistence units and the persistence length.

c) Size of a concentration blob in terms of R_{F0} and c/c*.

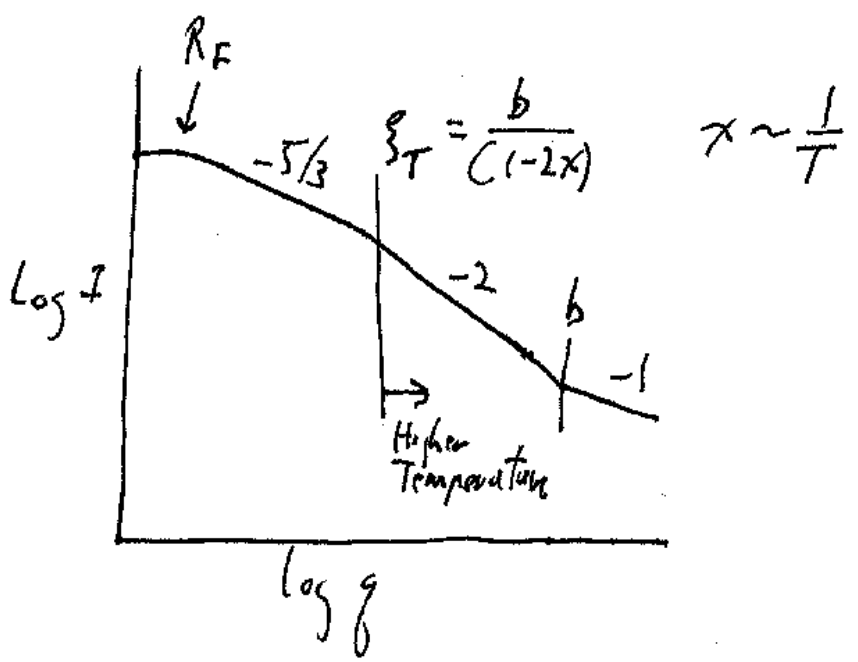
d) Size of a coil in the concentration blob regime in terms of R_{F0} and c/c*.

e) How would you demonstrate that your expression for the size of a concentration blob in concentration was correct?

ANSWERS: **030502 Quiz 5 Polymer Properties**

1) a) The screening length in the jungle model is the distance from the edge of the forest where you first can not tell the direction of the sunset.
b) "Mean field" corresponds to the non-directional glow of the trees around you deep in the forest.
c) Pitch black night would correspond to a mathematical random walk. You can not tell the direction west either in pitch black or when you are beyond the screening length.
d) The difference between a mathematical random walk and a random walk due to screening is that there is a field present, i.e. there is light, for the screening situation. This means that directionality can gradually be turned on or off depending on factors such as concentration and temperature. There are consequences to excluded volume other than directionality, e.g. the bulk density of the walk will change.
e) For fluorescent trees the screening length would be the distance from a specific tree where you could not distinguish the tree from which the light came. The mean field would be the average, background glow arising from fluorescent trees at distances greater than the screening length.

2) a) $d_f = 2$
b) This data is the classical support for the thermal blob model. At large scales (low-q) the chain is expanded, while locally the chain is Gaussian.
c) At a very high temperature the thermal blob would encompass the entire coil and the dimension would be 5/3, a power-law of -5/3 would be observed.
d)



e) Farnoux's plot is not consistent since the plot above shows I smaller than the extrapolated q^{-2} curve at low-q. This would mean 1/I should deviate in a positive way not a negative way at low-q. This discrepancy has never been discussed in the literature. (Other measurements have verified the thermal blob model. Farnoux's data appears to be in error, the statistics at high-q are not very good for Farnoux's data.)

3) a) $\xi_T \approx \frac{b}{(1-2\chi)}$

b) $c^* = N/R_{F0}^3 = N^{-4/5} b^{-3}$

c) $\xi_c \approx R_{F0}\left(\frac{c}{c^*}\right)^{-3/4}$

d) $R_F = R_{F0}\left(\frac{c}{c^*}\right)^{-1/8}$

e) This can be demonstrated by looking at a concentration series in deuterated solvent using neutron scattering. There are other ways to demonstrate this.