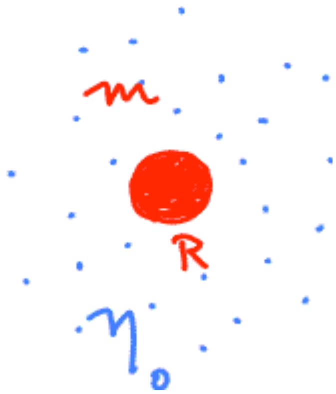
1.18. Polymer dynamics in dilute solutions:

1.18(a). General laws from Einstein:

Mean square displacement of a Brownian particle suspended in a solution:



$$\left\langle \left[\vec{R}_{CM}(t) - \vec{R}_{CM}(0) \right]^2 \right\rangle = 6\, D\, t$$

Stokes-Einstein law:

$$D = \frac{k_B T}{\zeta} = \frac{k_B T}{6 \pi \eta_0 R}$$

D = diffusion coefficient of the particle, ζ = friction coefficient

Viscosity of the solution (with n particles in volume V):

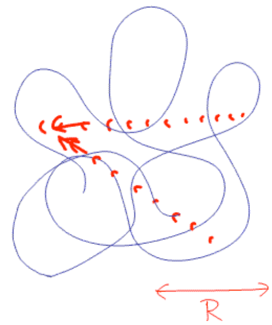
$$\frac{\eta - \eta_0}{\eta_0} = \frac{5}{2} \phi$$

where ϕ is the volume fraction,

$$\phi = \frac{4}{3} \pi \frac{n R^3}{V}$$

1.18(b). Zimm dynamics:

(accounting for hydrodynamic interaction)



(a) Diffusion coefficient:

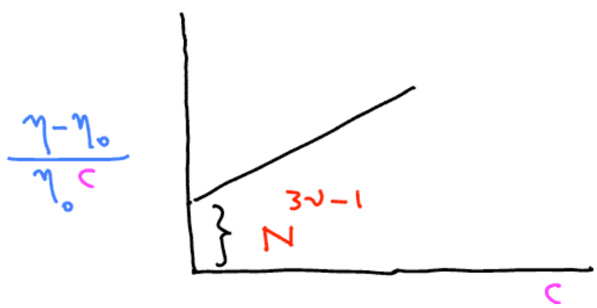
$$D = \frac{k_B T}{6\pi \eta_0 R} \sim \frac{T}{\eta_0 N^{\nu}} \sim N^{-\nu}$$

(b) Viscosity:

$$\frac{\eta - \eta_0}{\eta_0} = (\#)\, \frac{n R^3}{V} = (\#)\, \frac{n N}{V}\, \frac{R^3}{N}$$

$$\sim c\, N^{3\nu - 1}$$

(Intrinsic viscosity)

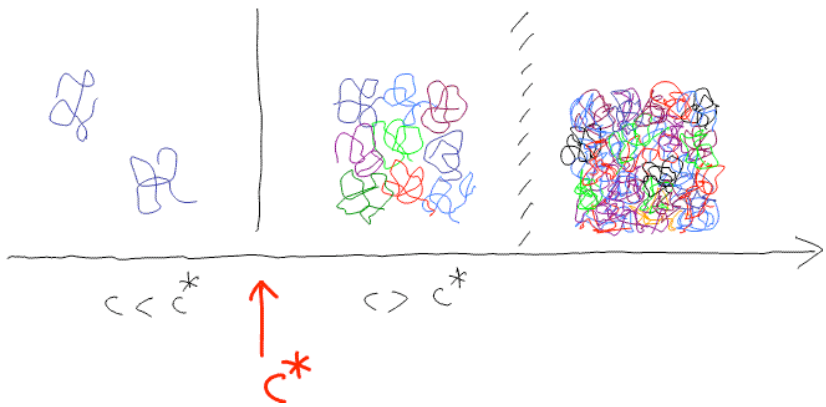


(c) Relaxation time: Time needed by a chain to undergo diffusion by a distance comparable to its R. Also, it is the time taken to relax to equilibrium if it were taken out of equilibrium.

$$\tau_{\text{Zimm}} \sim R^3 \sim N^{3\nu}$$

1.19. Concentrated polymer solutions:

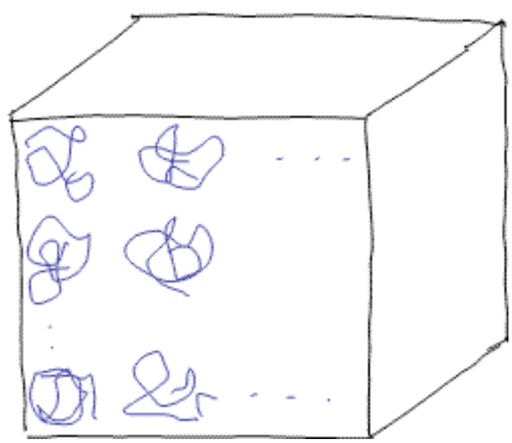
DILUTE SEMIDILUTE CONCENTRATED



(OVERLAP CONCENTRATION)

At the overlap concentration, c^*,

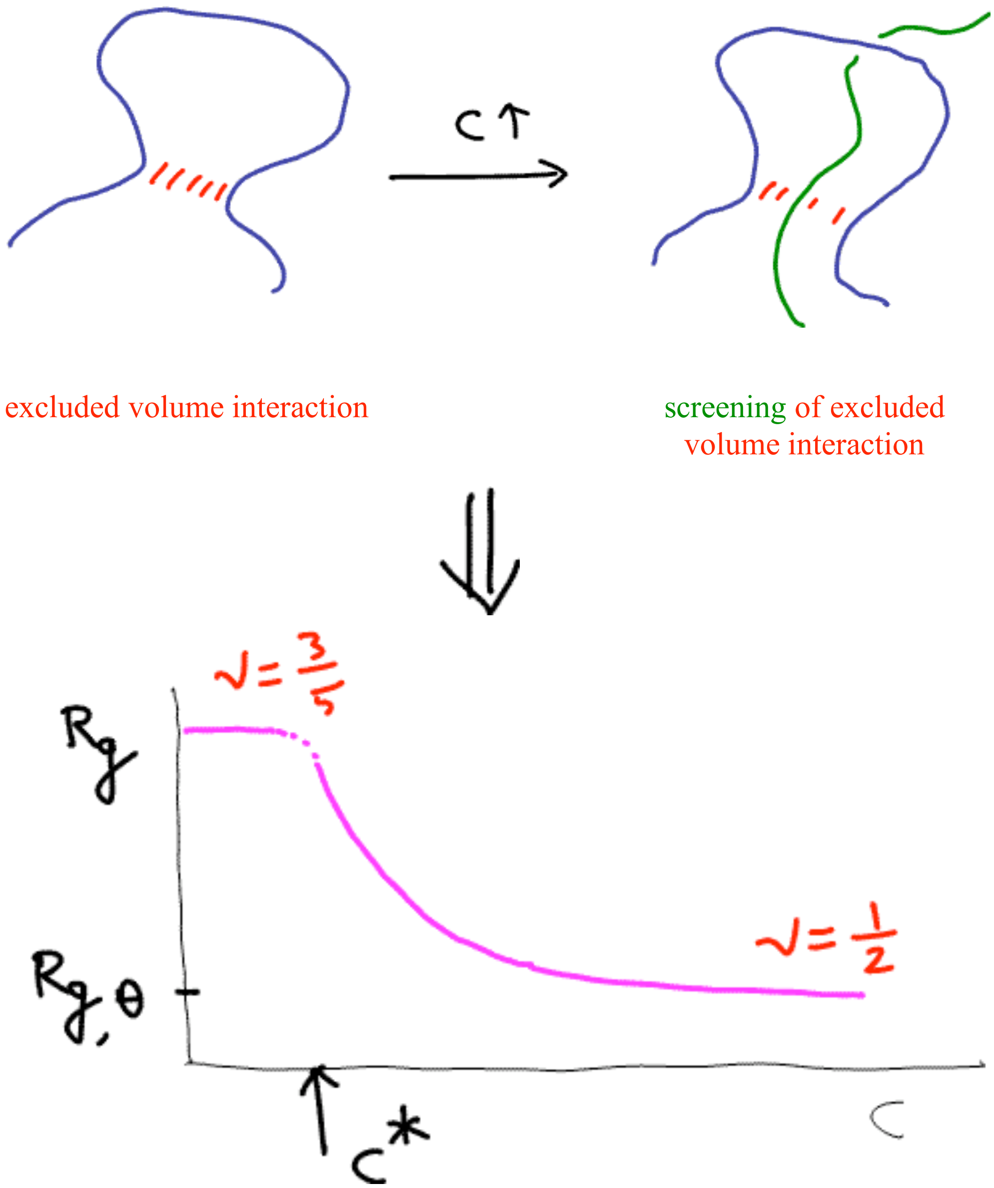
volume $\sim n R_g^3$



Therefore, the overlap concentration can be identified as:

$$c^* \sim \frac{n N}{n R_g^3} \sim N^{1-3\nu}$$

1.20. Screening of excluded volume interaction:



R_g of a labeled chain obeys Gaussian chain statistics in the melt (although is swollen in a good solvent). In semidilute solutions, it can be shown that

$$R_g \sim c^{-\frac{(\nu-\frac{1}{2})}{(3\nu-1)}} N^{1/2}$$