Basic Concepts in Polymer Physics
(Home assignments)

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Problem 1: Polymer in the free space by Equation of motion approach

Derive the end to end distribution of the free polymer (in 1D) by solving

$$-\frac{\partial}{\partial N}G(x,N;x',0) = -\frac{a^2}{6}\frac{\partial^2}{\partial x^2}G(x,N;x',0) \tag{1}$$

Use the form for general solution

$$G(x,N;x',0) = \int dk\psi_k(x)\psi_k^*(x')e^{-E_kN} \tag{2}$$

by finding $\psi_k(x)$ from

$$-\frac{a^2}{6}\frac{\partial^2}{\partial x^2}\psi_k(x) = E_k\psi_k(x) \tag{3}$$

Be careful with normalization of $\psi_k(x)$ since following boundary condition has to be satisfied

$$G(x,N=0;x',0) = \delta(x-x') \tag{4}$$

You will need following identities

$$\delta(x) = \int \frac{dk}{2\pi}e^{ikx} \tag{5}$$

$$\int dx\delta(x) = 1 \tag{6}$$

Problem 2: Polymer in free space by Random walk on lattice

Model the polymer as 1D random walk on lattice with lattice spacing a. Assume that probability of left and right jumps are same. Calculated the probability that random walker starting at x' arrives at x in N steps, call it $G(x,N;x',0)$. Find the large N limit for $G(x,N;x',0)$ using following approximation

$$N! \approx \left(\frac{N}{e}\right)^N\sqrt{2\pi N} \tag{7}$$

Problem 3: Polymer near unpenetrable wall by equation of motion approach

Same as problem 1, but with additional boundary condition on $\psi_k(x)$

$$\psi_k(x=0) = 0 \tag{8}$$

Also, try to study following special cases for $G(x,N;x',0)$

$$x = 0, x' \neq 0 \tag{9}$$

$$x \neq 0, x' = 0 \tag{10}$$

$$x - x' = const, x, x' \to \infty \tag{11}$$