Macromolecular Physics

Lecturer : Dr S Egelhaaf

Times: Semester 2. M, Th 0900.

Synopsis: Macromolecular Physics, or 'Soft Condensed Matter' is a relatively new and rapidly growing area of physics in which the School has a large research effort. The course will emphasise the basic physics of colloidal systems (microscopic particles suspended in a liquid), of polymers (large flexible 'macromolecules') and of surfactants (detergents). In many cases surprisingly simple models provide accurate descriptions of seemingly complex phenomena. For example the 'random walk' models both the Brownian motion of colloids and the shapes of polymer molecules and is used in the analysis of modern laser light, x-ray and neutron scattering experiments which provide information on the structure and dynamics of these intriguing systems.

Prerequisites: For 2004/2005: Physics 3 (H), or equivalent. Prior/concurrent attendance at Condensed Matter Physics and Statistical Physics is desirable. From 2005/2006: At least 70 credit points accrued in courses of SCQF Level 9 or 10 drawn from Schedule Q including Thermodynamics (PHY-3-Thermo) or equivalent. Prior attendance at Condensed Matter Physics (PHY-4-CondMatt) and Statistical Physics (PHY-4-StatPh) is desirable.

Syllabus

1. Introduction and motivation

2. The Random walk: One dimension - the binomial distribution. Large N limit - the Gaussian distribution. Mean and variance. Extension to two and three dimensions.

Part 1: COLLOIDS

3. Brownian motion - Einstein's approach: Connection with diffusion. Mean-square displacement. Stokes-Einstein equation. Gravitational length. Sedimentation equilibrium.

4. Brownian motion - Langevin equation: Physics of the Langevin equation. Transition from ballistic motion to diffusion. Time and length scales. Stokes-Einstein equation again.

5. Interacting colloidal particles: Samples. Phase behaviour with colloidal fluids, crystals and glasses. Particle dynamics.

Part 2: SCATTERING

6. Static light scattering: Average intensity as function of scattering angle. Form factor. Structure factor.

7. Dynamic light scattering: Rate of temporal fluctuations in scattered light. Correlation function. Determination of diffusion constant and hence size.

8. X-ray and neutron scattering: Scattering power. Flux. Length and time scales probed by the different techniques.

Part 3: POLYMERS

9. Chemical structure: Chemical make-up of common polymers.

10. Models for the conformation of polymers: Freely-jointed chain. Freely-rotating chain. Excluded volume effects.

11. Scattering by a polymer: Elastic scattering. Quasielastic scattering.

12. Polymer solutions: Overlap concentration.

13. Rubber: Examples. Elasticity.

Part 4: SURFACTANTS

14. Surfactants: Examples. Self-assembly. Micelle formation. Shapes of surfactant assemblies.

Part 5: VISIT TO LABORATORY

Recommended texts

Random Walk and Diffusion:

Fundamentals of Statistical and Thermal Physics, F. Reif, McGraw-Hill (1985), chapters 1 and 15.5 - 15.10.

Colloids:

Basic Principles of Colloid Science, D.H. Everett, Royal Society of Chemistry (1988).

Colloidal Dispersions, W.B. Russel, D.A. Saville and W.R. Schowalter, Cambridge (1989).

Scattering:

(No single book - detailed notes will be provided).

Polymers:

Giant Molecules, A.Y. Grosberg and A.R. Khokhlov, Academic Press (1997).

The Theory of Polymer Dynamics, M. Doi and S.F. Edwards, Oxford (1986), Chapters 1 and 2.