Welcome to the class! The name of the class had not been selected yet, but it should be nicer than “Not-necessarily-equilibrium statistical physics of soft matter”

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This course is designed to introduce the concepts of statistical physics, particularly the not-necessarily-equilibrium statistical physics, in the study of soft condensed matter of both biological and non-biological origin. Connections with other branches of physics will be emphasized.

NAME OF THE CLASS

No good name was invented so far for the class. The suggestions on how to name it are welcome throughout the semester. A good suggestion will be counted towards your final grade as one homework problem successfully solved.

MAJOR TOPICS TO BE INCLUDED:

1. Selection of topics from equilibrium statistical mechanics of polymers (e.g., flexibility and persistence length, ideal and non-ideal coils, coil-globule phase transition, Flory theorem and Edwards screening, nematic ordering);
2. Electrolytes (Debye screening, Poisson-Boltzmann mean field theory, charge correlations beyond the mean field - colloidal Wigner crystals, charge inversion);
3. Dynamics and kinetics (Rouse modes, hydrodynamic coupling, reptation, electrophoresis and electroosmosis, nucleation, spinodal decomposition);
4. Non-equilibrium statistical mechanics (work-energy theorems, commitment and reaction coordinate, transition path sampling);
5. Motors and ratchets.

This is an “ideal world” plan. In reality, because of time constraints, some of the topics will be only mentioned, while others will be developed to some depth.

PRE-REQUISITES

The class is designed for advanced graduate students. Although no sophisticated mathematics will be used, the sufficiently mature understanding across major physics disciplines is expected. No programming virtuosity is required, but simple computations are expected.

BOOKS AND OTHER SOURCES

There is no book which can serve as a single text for the class. Useful sources include, but are not limited to, the following books:


Additional reading from current journals will be assigned during the semester.

CONSTANTS AND UNITS

In this class, $c = \infty$ (nothing relativistic), $\hbar = 0$ (although quantum mechanical analogies are actively used), $k_B = 1$, $\epsilon_0 \to 4\pi \varepsilon_0$ (e.g., $\nabla \cdot \mathbf{E} = 4\pi \rho$), Avogadro’s number $N_A$ is not in use, i.e., concentration is defined as the number of molecules (not moles!) per unit volume, magnetic susceptibility of vacuum $\mu_0$ is also not in use.

In many (but not in all) cases, $2 \sim \pi \sim 2\pi \sim 1$.

HOME WORKS

The VERY IMPORTANT part of the course will be problem solving in every week home works. The solutions of some (not all!) home works will be handed out, they will be considered as a hand-out material and students will be expected to study them carefully, like a text.

Each student will be expected to present a paper (not necessarily publishable) on one of the subjects in the class.

In general, a significant amount of reading and thinking will be expected to succeed in class.

Grading will be mostly based on the home works and papers.