Physics of soft matter 2019/20

week		lectures		tutorials
1	1. 10.	Introduction. Phenomena and features of soft matter. Interparticle forces, Viscoelastic response, microscopic interpretation of elasticity and viscosity. Generalized susceptibility.	1. 10.	*(lectures)*
2	8. 10.	Liquid state I. Equilibrium themodynamics, ideal and excess quantities. *n*-particle densities and *n*-particle distribution functions. Radial distribution function. YBG hierarchy. Distribution function theories, Ornstein-Zernike equation. Virial expansion.	8. 10.	*(lectures)*
3	15. 10.	Liquid state II. Hard-sphere equation of state: Carnahan-Starling equations of state. Perturbation theories: λ-expansion, van der Waals equation of state.	15. 10.	▪ Kelvin-Voigt and Maxwell model of viscoelastic media (TP)
4	21. 10.	Liquid crystals I. Onsager theory. Elastic theory of nematics: Director, Frank elastic energy, splay, twist and bend deformations.	21. 10.	▪ Third virial coefficient for hard spheres (TŽ) ▪ Thermodynamic inconsistency (ML) ▪ Derivation of Ornstein-Zernike equation* ▪ Closures of Ornstein-Zernike equation (MO)
5	28. 10.	Liquid crystals II. Surface anchoring: Extrapolation length; twisted cell. Nematic in magnetic field. Line defects: classification, strength, energy, stability.	28. 10.	▪ Maier-Saupe theory of isotropic-nematic phase transition ▪ Hybrid nematic cell (ŽF) ▪ Nematic liquid crystal in a capillary: escaped vs. planar radial structure (NK)
6	5. 11.	*(tutorials)*	5. 11.	▪ Anchoring of liquid crystal at grooved substrate (BM) ▪ Frederiks transition (KK)
7	12. 11	Liquid crystals III. Tensorial nematic order parameter. Landau-de Gennes theory of nematic-isotropic transition. Smectic elasticity: Order parameter, layer compression and bending.	12. 11	▪ Landau-de Gennes theory of nematic-isotropic transition (TK) ▪ Blue phases (TK)
8	19. 11.	Polymers I. Single polymer chain: Freely jointed chain, radius of gryation, entropic elasticity. Persistence length. Expanded coil. Coil-globule transition.	19. 11.	▪ Path integral formalism for polymers (RK) ▪ End-to-end distance in worm-like chain (PA) ▪ Elongation on force in freely-jointed chain model
9	26. 11.	Polymers II. Polymer solutions: dilute, semidilute, and concentrated solutions, osmotic pressure; des Cloizeaux formula. Dynamical models: Rouse modes, reptation.	26. 11.	▪ Adsorption of a single chain (JG) ▪ Problems with Flory theory (JZ) ▪ Scaling theory of confined polymers: between two walls, in a cylindrical capillary (AK)
10	3. 12.	Polymers III. Gels: Flory-Stockmayer theory. Rubber.	3. 12.	▪ Rubber elasticity & Mooney-Rivlin model (AP)
11	10. 12.	Colloids I. Classification, characteristic energies. Brownian motion: Einstein-Stokes relation. van der Waals forces: nonretarded and retarded interaction; Casimir interaction.	10. 12.	▪ Derjaguin approximation (ML) ▪ Hydrodynamic interaction between two spheres (MR)
12	17. 12.	Colloids II. Electrostatic interaction: screening, Poisson-Boltzmann equation, Debye-Hueckel approximation, force between like-charge plates. Depletion interaction. Derjaguin-Landau-Verwey-Overbeek theory. Aggregation and stabilization of colloids. Phase diagram of hard spheres.	17. 12.	▪ Interacting charged surfaces on the Poisson-Boltzmann level (AH) ▪ Interacting charged surfaces at fixed electrostatic potential (KT) ▪ Manning condensation ▪ Diffusion-limited aggregation (TŽ)
13	24. 12.	*TBA*	24. 12.	*TBA*
14	31. 12.	*TBA*	31. 12.	*TBA*
15	7. 1.	Amphiphiles I. Types of micelles, critical micelle concentration. Spherical micelles; cylindrical micelles: distribution of micelle size; bilayers.	7. 1.	▪ Limiting shapes of unilamellar vesicles (MG) ▪ Complex amphiphile/diblock copolymer morphologies: perforated lamellar, sponge, gyroid phases
16	14. 1.	Amphiphiles II. Theory of membrane elasticity: bending and stretching moduli. Vesicles: reduced volume, ADE theory, vesicle shapes.	14. 1.	▪ Persistence length of a bilayer membrane ▪ Helfrich free energy & undulation forces ▪ Plastic deformation of a 2D foam
17	21. 1.	*(tutorials)*	21. 1.	*(tutorials)*