A - Shared between iCFP tracks: 7 weeks
â€œBroken symmetries, critical phenomena & renormalisationâ€

I Introduction to phase transitions and critical phenomena
1- The problems raised by phase transitions, from a statistical mechanics perspective
2- Classification of phase transitions
3- Ising model : The drosophila of phase transitions
4- Order parameter and symmetry breakdown
5- Local order and correlation functions : from magnets to liquids

II First order phase transitions
1- Unstable isotherms, double-tangent and Maxwell construction
2- Spinodal and binodal
3- Changing ensembles
4- van der Waals equation
5- The case of mixtures

III Critical phenomena : qualitative approaches
1- Weiss molecular field
2- Variational mean-field
3- Critical exponents
4- Landau theory
5- Correlation functions and Ginsburg-Landau functional
6- Validity of mean-field

IV Renormalisation group ideas
1- What are the problems ?
2- Definition of a renormalisation group transformation
3- Fixed points and universality
4- Scale invariance, critical exponents, and finite size scaling
5- Two-dimensional systems and conformal invariance

TDs:
1. Fluctuation theorems & single molecules
2. Nematic liquid crystals: phase transitions & field theory
3. Percolation (?)

B - specific to the Soft Matter & Biophysics track
â€œMoving away from equilibriumâ€

V Linear response at equilibrium [discrete variables]
1- Dynamics of a fluctuating quantity: the Langevin equation
2- Einsteinâ€™s law: a strange coincidence?
3- Time-dependent correlation and response functions
4- The fluctuation-response theorem
5- Onsagerâ€™s reciprocity relations

VI Response out of equilibrium [discrete variables]
1- â€œBreakingâ€ the fluctuation-response theorem?
2- Oscillations of the hair bundle

3- Mending the fluctuation-response theorem

VII Generalized hydrodynamics [fields]

1- Intro : the diffusion equation is generalized hydrodynamics theory
2- Conserved quantities and broken symmetry variables relax slowly
3- Fluxes & forces at the linear response level
4- Thermodynamic constraints on the phenomenological coefficients & active terms

VIII Active matter

1- An active polar fluid model [malthusian flock?]
2- Birds & nerds: flocking
3- Phase separation
4- Pressure is not a state variable [?]

Possible TDs:

- the fluctuation-response theorem for a Langevin dynamics
- Violations of the fluctuation-response relations in a trap model
- From a microscopic model to a hydrodynamic theory : a kinetic theory example
- Giant number fluctuations in a non-malthusian flocking model with noise