The Abdus Salam
International Centre for Theoretical Physics

United Nations Educational, Scientific and Cultural Organization

IAEA International Atomic Energy Agency

School and Conference on Mathematics and Physics of Soft and Biological Matter

(2-13 May 2011)

Mini-Courses

M. Cristina Marchetti

Collective Dynamics of Active Matter

Lecture 1: Introduction
- ï What are active systems?
- ï Vicsek model (briefly)
- ï Hydrodynamics: symmetries, conservation laws and broken symmetries.
- ï Orientational order; Polar vs apolar systems
- ï Tutorial: phenomenological formulation of the hydrodynamics of an isotropic fluid.

Lecture 2: Hydrodynamics of ìLiving Liquid Crystalsî I
- ï Tutorial: hydrodynamics of nematic liquid crystals
- ï Active hydrodynamics: active stresses, nematic versus polar order (again)
- ï Linear modes and instabilities

Lecture 3: Hydrodynamics of ìLiving Liquid Crystalsî II
- ï Spontaneous flow in active films
- ï Asters, vortices and spirals
- ï Rheology of active suspensions

Lecture 4: Form Microdynamics to Hydrodynamics ñ Active Particles on a Substrate
- ï Tutorial: Langevin, Fokker-Planck and Smoluchowski dynamics
- ï Hydrodynamics of SP hard rods
- ï Hydrodynamics of Vicsek model
- ï Giant number fluctuations, instabilities, persistent diffusion, enhanced nematic order
- ï Comparison with experiments in vibrated granular layers and actin motility assays

Lecture 5: Continuum theory of active solids
- ï Spontaneous oscillations in biological systems
- ï Continuum model of active gels and bundles

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Mark Warner

Elastomers, both classical and neo-classical - the ultimate soft solids

1. Liquid Crystals; polymers, classical rubber elasticity ñ molecular basis, statistical mechanics.
Liquid crystalline polymers.

2. Non-linear elasticity - geometric and constitutive considerations, det{\lambda} = 1.
Shear and elongation in volume-conserving deformations; rotational invariants, material frame indifference.
Decomposition of deformations into pure shear and rotations.

3. Nematic elastomers. Molecular basis of a new free energy.
Spontaneous distortions (plus photo-mechanics).
Soft elasticity; its connection with spontaneous distortions and with Golubovic and Lubensky (GL).
Semi-soft elasticity. Practical methods of calculating deformations.
Stripes; first steps towards DeSimone quasi-convexification.

Reference:
Lecture notes downloadable from web

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Tom Powers

Swimming micro-organisms

1 Overview of swimming mechanisms and low Reynolds number flow

2 Swimming sheets and slender body theory

3 Physical actuation

4 Hydrodynamic interactions

5 Swimming in complex fluids

Reference:
http://dl.dropbox.com/u/652169/LaugaPowers2009.pdf

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Fred MacKintosk

Elasticity of fibrous networks and implications for cell mechanics

Lecture 1:
- cytoskeletal and extracellular filament types and properties
- single-filament mechanics, fluctuations, persistence length
Lecture 2:
- force-extension relation and dynamics of single-filaments
Lecture 3:
- solutions and networks of semi-flexible polymers
Lecture 4:
- nonlinear elasticity of networks
Lecture 5:
- fluctuation-dissipation theorem and non-equilibrium fluctuations

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Julie Plastino

Cytoskeleton and cell motility

1. Introduction to actin cytoskeleton and motility ; biomimetic systems (Listeria, beads, patterns)
2. The moving cell: force production, retrograde flow, substrate sensing
3. Membrane and cytoskeleton: blebbing phenomenon, tether experiments
4. Acto-myosin cytoskeleton in collective cell migration and morphogenic movements

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