BuildMoNa

UNIVERSITÄT LEIPZIG

SCIENTIFIC AND METHOD MODULES

Module name	Theory: Structure and Mechanics of Foams and Cellular Matter
Number	2011-M03
Aims	The module aims at providing the scientific background required to study foams and other synthetic and natural cellular materials. Participants shall learn about the basic physical principles to understand foams and cellular structures on the basis of their microstructure and topology, and about their significance for biological tissues and morphogenesis.
Basics	The topics covered in statistical mechanics, soft matter and biophysics lectures from the existing master program; basic knowledge about free energies, surface tension, elasticity, viscoelasticity, statistical physics
Contents	Physical principles of foams and cellular materials. Review of basic principles of soft matter physics. Structure and mechanics/dynamics of foams and cellular matter. Coarsening. Rheology and mechanics of foams. Mechanics of networks. Introduction to Surface Evolver and foam structure exercises. Physical principles responsible for the structure of cell assemblies, growth, and morphogenesis.
Methods	Statistical mechanics & theoretical modeling of cellular structures and topologies, rheology and mechanics, Minkowski functionals, free energies, variational principles, computer simulations
Type	Two-day block course/ yearly recurrence with modification
Date (month/year)	22.9.-23.9. 2011
Time	9:00 – 17:30, 9:00 – 17:30
Work load	15 hours presence/ 45 hours self-study
Examination	written exam 4.10.2011
Credit points	2
Responsible scientists	K. Kroy, W. Janke
International guest lecturers	Sascha Hilgenfeldt (University of Illinois) Andrew Kraynik (Sandia National Labs), Douglas B. Staple (MPPKS Dresden)
	Introductory: David Boal, Mechanics of the Cell, Cambridge Univ. Press (2002); Ken A. Brakke, Surface Evolver, documentation on http://www.susqu.edu/brakke/evolver/evolver.html D. Weaire and S. Hutzler, The Physics of Foams, Oxford University Press (2000) L. D. Landau, E. M. Lifshitz, Theory of Elasticity (vol. VII of Theo- retical Physics), Butterworth (1995); Udo Seifert, Fluid membranes - theory of vesicle conformations, KFA Jülich print #2997 (1994); R. D. Kamien The geometry of soft materials: a primer, Rev. Mod. Phys. 74, 953 (2002) Further Reading: S. Hilgenfeldt, A. M. Kraynik, et al., The structure and properties of random foam: isotropic Plateau polyhedra, Europhys. Lett. 67, 484 (2004); S. Hilgenfeldt, S. Erisken, and R. Carthew, Physical modeling of cell geometric order in an epithelial tissue, Proc. Natl. Acad. Sci. USA 105, 907 (2008); D. B. Staple *et al.,* Mechanics and remodelling of cell packings in epithelia, Eur. Phys. J. E 33, 117 (2010); Reza Farhadifar *et al.*, The Influence of Cell Mechanics, Cell-Cell Interactions, and Proliferation on Epithelial Packing, Curr. Biol. 17, 2095 (2007).

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SCHEDULE 2011

Time	Lecturer	Title
22.9.2011		
09:00-10:30	A. Kraynik	Structure of Liquid Foam
10:30-12:00	A. Kraynik, S. Hilgenfeldt	Introduction to Surface Evolver and Foam Structure Exercises
LUNCH	(served on site)	
13:00-14:30	A. Kraynik	Diffusive Coarsening of Foam
14:30-16:00	S. Hilgenfeldt	Von Neumann's Law and Minkowski Functionals
16:00-17:30	A. Kraynik	Rheology of Liquid Foam
DINNER		
23.9.2011		
09:00-10:30	A. Kraynik	Mechanics of Solid Foams
10:30-12:00	S. Hilgenfeldt	Mechanics of Networks, with Surface Evolver Exercises
LUNCH	(served on site)	
13:00-14:30	S. Hilgenfeldt	Continuum mechanics and Variational Principles for Soft-Matter systems, with Surface Evolver exercises
14:30-15:30	S. Hilgenfeldt	A Mechanical Model for Shape and Morphogenesis of the Fly Eye
15:30-17:30	D. Staple	Morphogenesis of the Fly Wing

Didactic elements:
Lectures, plenary discussions and exercises with computer program “Surface Evolver” etc.

Expected performance:
Active participation in discussions, exercises, computer exercises, and written examination