Abstract. The subject of this meeting was mathematical modeling of strongly interacting multi-particle systems that can be interpreted as advanced materials. The main emphasis was placed on contributions attempting to bridge the gap between discrete and continuum approaches, focusing on the multi-scale nature of physical phenomena and bringing new and nontrivial mathematics. The mathematical debates concentrated on nonlinear PDE, stochastic dynamical systems, optimal transportation, calculus of variations and large deviations theory.

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Introduction by the Organisers

New mathematics usually originates from problems suggested by the neighboring fields of science. In this sense this interdisciplinary workshop is a unique asset for the mathematical community and it plays an important role of the incubator of new ideas, allowing participants to transform physical insight into rigorous mathematical theories.

The goal of the meeting was to expose the mathematics community to new and exciting developments in the fields of Mechanics of Materials, Statistical Physics and Biology. The subjects discussed at the workshop were quite diverse, ranging from martensitic phase transitions and ductile fracture to plant morphogenesis, unicellular swimmers, and active matter.

The program included 21 keynote lectures, and considerable time was given to discussions initiated by the talks. Among the topics raising particular interest
were: new methods of analysis of the buckling of cylindrical shells by Y. Grabovsky, new approaches to ductile fracture by M. Ortiz, new perspectives on Hadamard compatibility condition by J. Ball, microscopic theory of pre-stress in binary alloys by P. Smereka, insights into the origin of configurational forces through experiments on elastic structures by D. Bigoni, study of microstructures based on optimal scaling of the energy by F. Otto and F. Theil and a discrete theory of surface energy in crystals by P. Rosakis. An interesting discussion of dislocation mechanics was initiated by two talks: by A. Garroni, from the point of view of modern calculus of variations and by A. Yavari from the point of view of geometric mechanics. G. Francfort presented a new perspective on homogenization in macroscopic plasticity. T. Lelievre reviewed recent progress in the theory of accelerated methods in molecular dynamics. A novel method of capturing both coarse grained behavior and fluctuations by using the theory of large deviations and Gamma convergence was presented by M. Peletier. A. Mielke showed the possibility of re-writing reaction-diffusion systems as flows with a gradient structure, provided that detailed balance is satisfied. Y. Brenier discussed a new class of minimization problems under rearrangement constraints, originally motivated by a problem in fluid mechanics related to stationary solutions of 2D Euler equations. The asymptotic behavior of thin bodies was the subject of two talks: by G. Bouchitte in the nonlinear elasticity framework and by B. Audoly in plasticity theory. B. Schmidt reported new results in the problem of simultaneous geometric linearization and homogenization of multi-well energy functionals. Finally, biology was represented by theories of plant growth (A. Boudaoud), cell motility (M. Arroyo) and collective interactions in bacterial suspensions (E. Clement).

By exposing participants to a broad spectrum of subjects and techniques, all centered on the mechanics and thermodynamics of materials, the workshop created an atmosphere conducive to new collaboration between researchers with complementary expertise who had little chances to cross paths otherwise. The organizers were able to witness the success of this idea from the liveliness of the discussions during and after the talks, and from the active involvement and enthusiastic response of junior participants. This workshop has been in the past a source of many collaborations and this one promises to be no exception.
Workshop: Material Theories

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