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07pims006: Mechanical behavior of disordered materials

Organizers:

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Location:

University of British Columbia

PIMS Sites:

University of British Columbia

Objectives:

Glassy or amorphous structures are found in a surprisingly broad range of solids that range from structural materials such as polymer and metallic glasses to "soft" colloidal glasses, biomolecular networks and granular media as well as magnetic materials (spin glasses). An understanding of the mechanical behavior of such materials, for instance their responce to external fields such as stress or strain, is both a fundamental challenge to statistical and condensed matter physics as well as of great practical importance in engineering applications. This 3-day workshop is part of PITPs collaborative research team on "Complex Systems" and aims to bring together researches working on new mathematical and computational modeling techniques that hold the promise of elucidating the out-of-equilibrium behavior of such disordered materials.

Comments:

The nonequilibrium dynamics of disordered systems continues to present a fundamental challenge to theoretical physics. The presence of frustration, be it self-generated as in structural glass formers or quenched as in spin-glasses, gives rise to intriguing phenomena such as slow dynamics, history dependence, spatial heterogeneity, etc and provides an ideal testbed for extensions of equilibrium statistical mechanical concepts to far from equilibrium situations. Glassy behavior is found in a wide range of condensed matter systems including polymers, metallic alloys, spin glasses (magnetic systems) and many soft materials such as colloids, foams, emulsions or other complex fluids. Many biological systems, most importantly proteins, also exhibit glassy phenomenology. The nature of the glass transition itself (thermodynamic or kinetic phenomenon) is still unresolved.

Significant effort is currently being invested in improving our understanding of the mechanical properties of structural glasses, which, unlike crystalline systems, is not dominated by topological defects such as dislocations. A fundamental understanding of the microscopic mechanism of deformation in such amorphous solids is still lacking. Possible mathematical approaches include (free) energy landscape pictures, mean field rate equation descriptions of internal state variables, as well as computer modeling and simulations of atomistic and coarse-grained models. Fruitful parallels can be drawn between driven structural glasses and spin (magnetic) glasses. Through work on simplified models that are amenable to exact mathematical treatment, progress has recently been made to extend the notion of temperature, a concept from equilibrium thermodynamics, to systems with nonstationary dynamics. The predictions of such promising approaches can be tested against experiments and simulations.

While these methods are aimed at addressing the high-temperature behavior, it is quantum effects that take over the leading role at low temperatures. This workshop will therefore contrast our understanding of the origins of the behavior of disordered solids and other complex materials at high temperatures to quantum glasses at low temperatures. To this end, we will select a rather broad range of speakers in order to explore different kind of materials that range from structural glasses and magnetic glasses to complex biomolecular assemblies such as cytoskeletal networks. Many scientists have simultaneous research programmes adressing more than one class of systems. The speakers will provide theoretical, experimental and computational perspectives. This will provide a unique opportunity for the workshop to identify common threads and differences and stimulate fruitful interactions and synergies. There is significant local interest in the topics of this workshop both at UBC and at SFU.

We intend to hold this workshop during May/June 2007 for a period of

3 days on the UBC campus. The conference organizers are junior faculty members in the Department of Physics at UBC and SFU, respectively. Dr. Kennett has worked extensively on analytical models and simulations of spin glass dynamics and spatial heterogeneities. Dr. Rottler focuses instead on molecular simulations of structural glasses. Their research programs combined with the historical strengths of UBC in single molecule mechanics and of SFU in biomaterials form an ideal and timely starting point for this workshop.

Audience:

The meeting will be primarily aimed at expert researchers working in the field in order to be able to address the latest developments. Advanced graduate students and postdocs should likewise benefit from the workshop. In addition to oral presentations we plan to hold at least one poster session on one of the evenings of the meeting in order to provide an opportunity for students and non-speakers to present their results. The poster session will be open to every participant in the meeting.

Participants:

We intend to invite about 20 speakers for a three day workshop from the list below.
All invited speakers will give a 30-45 min lecture.
Final selection and invitations will occur once full funding for the meeting is secured.

Keynote speakers:

J. Langer, UCSB, Glass transition and shear transformation zone theory
J.L. Barrat, Universite Lyon 1, Continuum mechanics of amorphous systems
W. van Saarloos, Lorentz institute, Granular flow and/or complex fluids
D. Weitz, Harvard, colloidal glasses, soft condensed matter
E. Evans, UBC and BU, single molecule biophysics experiment
A. Libchaber, Rockefeller University, biological materials
M. Robbins, JHU, multiscale modeling approaches to deformation and fracture
D. Osheroff, quantum glasses
A. Leggett, quantum glasses and condensed matter physics

Other possible speakers:

P. Sollich, London, soft glassy rheology
M. Falk, Michigan, Shear localization in metallic glasses
C. Ohern, Yale, Effective temperatures, jamming
N. Provatas, Princeton/McMaster, Phase field crystal approach to plasticity
J. Harden, Ottawa, Yield stress fluids

B. Joos, Ottawa, Aging in polymer glasses
J. Vinals, McGill, Nonequilibrium stat mech approaches, pattern formation
C. Maloney, JHU Amorphous plasticity.
J. de Pablo, Wisconsin, simulation and modeling of glassy polymers
A. Liu, Penn, theory of jamming and biopolymers
J. Carlson, UCSB, modeling of plasticity in amorpous solids; complex systems
B. Frisken, SFU, Experiments on yield stress fluids
D. Reichman, Columbia, mode coupling approaches to deformation and flow
L. Cugliandolo and/or J. Kurchan: effective temperatures, vortex glasses
D. Lacks, Case Western Univ., amorphous plasticity
M. Ediger, Wisconsin, polymer experiments
M. Moore, Manchester, spin glasses
M. Cieplak, Polish Academy of Sciences, mechanical protein unfolding
V. Viasnoff, ESPCI, single molecule experiment
J. Fernandez, Columbia, single molecule experiment
N. Forde, SFU, Protein stretching experiment
P. Geissler, Berkeley, biomolecular networks
F. Mackintosh, Amsterdam, semiflexible networks
A. Levine, UCLA, semiflexible networks
C. Yu, UCSD, spin and coulomb glasses

Other expected participants (not necessarily speaking):

S. Plotkin, Physics, UBC
J. Rottler, Physics, UBC
G. Sawatzky, Physics, UBC
P. Stamp, Physics, UBC
G. Patey, Chemistry, UBC
J. Feng, Chemical Engineering, UBC
J. Thewalt, Physics, SFU
M. Kennett, Physics, SFU
J. Bechhofer, Physics, SFU
M. Zuckerman, Physics, SFU

+ graduate students and postdocs from the research groups led by the above faculty members.

Amount Requested:

10000.00

Expenditures:

Accomodation for 20 invited speakers
(4 days @ $80/person): 4 x 20 x $80 = $6,400

Airfare and other transportation
($1500/person) 20 x $1500 = $30,000
Coffee breaks, AM/PM snacks
($8/person/day) 3 x 40 x $8 = $960
Lecture hall rental
($250/day) 3 x $250 = $750
Conference dinner
($50/person) 40 x $50 = $2000

Total $40,110

Income:

The PITP has already committed $10,000 to fund this PITP activity. We are asking for additional funding from PIMS to realize this 3 day workshop in the form of about 20 invited speakers from Europe and North America. In addition, PITP will make avaiable its administrative resources and facilities for the organization of the meeting. We anticipate to raise the remaining funds through contributions from SFU, various departments at UBC including Physics and from sources outside Canada.

Selected Dates:

Tue, May 1, 2007
Fri, June 15, 2007