MECHANICAL ENGINEERING SEMINAR

Monday, June 9, 2025 at 14:30, D. Dan and Betty Kahn Building, Room 217

Also online: https://technion.zoom.us/j/96755730569

Computational Multiphysics, High-Performance Computing, & Sensors

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This seminar presents ongoing research dedicated to the development of physical models, computational methodologies and sensor concepts based on dynamical systems and continuum mechanics approaches. It gives an overview of several sensing technologies designed to detect e.g. electrostatic-field nonuniformities, hazardous gas concentrations, mechanical motion/position changes, fatigue-related damage in metals, etc.

These sensor concepts are designed based on nonlinear dynamical systems theory and multiphysical-interaction models, as well as dedicated numerical solvers for continuum mechanics problems — several examples being finite-element and spectral solvers for PDEs, order-reduction and modal decomposition methods for ODEs and various asymptotic procedures.

A detailed discussion is given on the recently developed automaton-form-based mesoscopic theory of crystal plasticity. A hybrid smooth–nonsmooth formulation is introduced, which models plastic deformation as a quantized process enabling the reproduction of experimentally observed critical exponents. This approach allows the simulation of intermittent plasticity in crystals with computational speedup of approximately two orders of magnitude w.r.t. previous (smooth) formulations.

While microscopic theories, such as discrete dislocation dynamics (DDD), continuum dislocation dynamics (CDD), etc., resolve atomic-scale configurational patterns in plastic deformation of real crystalline materials, they are computationally limited to small, sub-structural systems. On the other hand, macroscopic theories, e.g. standard/classical crystal plasticity, which are computationally efficient for engineering-scale systems, lack fundamental rigor, often relying on heuristic relations (e.g. effectively-isotropic yield, continuous plastic flow rules, strain hardening laws, etc.). The proposed mesoscopic approach constitutes an advantageous compromise between the two limits, both from the theoretical perspective and from the point of view of possible applications.

Dr. Nathan Perchikov has obtained his BSc and MSc degrees in the School of Mechanical Engineering at Tel Aviv University. The MSc thesis entitled "Optimal stiffening of rectangular plates in elastostatic bending". He later obtained his PhD degree in Nonlinear Dynamics of Systems with Internal Symmetries at the Faculty of Mechanical Engineering at the Technion, under the guidance of Prof. O.V. Gendelman. Subsequently, he was a postdoctoral researcher at the Sorbonne Université in Paris, France, at the CNRS Lab PMMH (Physique et Mécanique des Milieux Hétérogènes) and at the Max-Planck-Institut für Eisenforschung in Düsseldorf, Germany.