MECHANICAL ENGINEERING SEMINAR

Monday, June 26, 2023 at 14:30, D. Dan and Betty Kahn Building, Auditorium 1

Online: (optional zoom) **YES/ send us the zoom link**

A solution to amorphous elasticity and plasticity based on newly discovered topological defects

Alessio Zaccone, Ph.D.

Professor of Condensed Matter Physics

University of Milan, Italy

Email: alessio.zaccone@unimi.it; Website: https://www.unimi.it/en/ugov/person/alessio-zaccone

Hosted by: Prof. Oleg Gendelman

I will start by reviewing the microscopic theory of linear elasticity in amorphous solids which, from first-principles consideration of non-centrosymmetry in the particle contact environment, leads to mathematical predictions of elastic moduli in quantitative parameter-free agreement with numerical simulations of e.g. random jammed packings. This theory fully accounts for the extra non-affine displacements which arise due to the lack of centrosymmetry that leads to force imbalance in the so-called "affine" position, with characteristic negative (softening) contributions to the shear modulus entirely due to non-affine displacements. I will then show how the theory can be systematically extended to linear viscoelasticity, again in excellent parameter-free agreement with mechanical spectroscopy (oscillatory rheology) in simulations of polymer glass rheology. I will then show that non-affinity of particle motions gives rise to well-defined topological defects (dislocation-like topological defects, DTDs) which have recently been discovered in the displacement field of model amorphous solids and later confirmed by W. Kob and coworkers. The norm of the associated Burgers vector of these defects can be used as an accurate predictor of plastic events and of the onset of plastic flow and yielding of the amorphous material, and, in combination with Schmid's law, it can explain the phenomenon of shear banding via self-organization of DTDs in slip systems at 45 degrees with respect to flow direction. Broader implications of a unifying topological field theory of liquids and the liquid-solid transition will also be mentioned.

Professor Alessio Zaccone received a PhD in Chemical Physics from ETH Zurich in 2010. He served as a faculty member at the Technical University Munich, at the University of Cambridge, and, currently, at the University of Milan. His active research interests include jamming and granular packings, the physics of glasses and amorphous solids, elasticity, phonons and continuum mechanics, topological physics, statistical mechanics, colloids, liquids and complex fluids out of equilibrium, and the theory of superconductivity. In 2022 he received an ERC Consolidator grant from the EU. In 2020 he received the Gauss Professorship of the Goettingen Academy of Sciences.

Seminars Coordinator: Assoc. Prof. Matthew Suss.