הטכניון מכון טכנולוגי לישראל TECHNION Israel Institute of Technology

Faculty of Mechanical Engineering הפקולטה להנדסת מכונות

MECHANICAL ENGINEERING SEMINAR

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Modeling the Rheology and Mechanics of Complex Fluids – Two Stories

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Hosted by: Prof. Oleg Gendelman

Many complex fluids are emulsions or dispersions, i.e., multicomponent systems where the "particles" or "droplets" of a dispersed phase are distributed within the continuous-phase matrix. (If the "matrix" is "solid", we usually talk about "composites" and use composite mechanics models). These fluids have variety of applications (Food industry, Pharmaceutical industry, Electronics, Water desalination, Agriculture, Paints and Coatings, and many others). Materials scientists and chemical engineers need to develop complex, multiscale models to predict the rheology and mechanics of such fluids at different temperatures and frequencies or shear rates.

Here, I discuss two examples. One (with Prof. Ron Larson, University of Michigan, and other collaborators) is related to waterborne paints with associative thickeners called HEUR (hydrophobically ethoxylated urethanes). The latex/water/HEUR dispersions are characterized by rheological measurements and described by multiscale computer models. The viscosity and shear moduli (storage and loss) are strongly non-Maxwellian. Such a behavior is due to formation and breakage of polymer "bridges" between particles, leading to the formation of transient network of bridged particles (TNBP). These hybrid networks typically are characterized by power-law relaxation time spectra that recently gave rise to new mathematical approach known as Fractional Calculus (FC). Thus, my second example (with Prof. Mohsen Zayernouri, Michigan State University, and other collaborators), deals with the use of FC modeling to characterize the rheology of segmented polyurethanes (PU) and their nanocomposites with graphene nanoplatelets. We show that the use of fractional Maxwell models (FMM) allows us to successfully describe the linear rheology of PU materials over wide ranges of frequency and temperature. As the use of FC becomes more widespread, I conclude by discussing potential opportunities for its application in various emulsion and dispersion fluids.

Seminars Coordinator: Assoc. Prof. Shmuel Gal.

Valeriy Ginzburg was born in Kharkiv (USSR, now Ukraine) in 1966. He has earned his B. S. (Physics) in 1989, and Ph. D. (Polymer Physics) in 1992 at the Moscow Institute of Physics and Technology ("FizTech") in Russia. After postdoctoral fellowships at the University of Colorado (1993-97) and the University of Pittsburgh (1998-2000), he worked at The Dow Chemical Company (2001-2020). Today, he is a visiting professor at Michigan State University and founder of a consulting company VVG Physics Consulting LLC. Dr. Ginzburg is a co-inventor on 15 US patents and author or co-author of about 100 journal publications, including several in Physical Review Letters, Science, and Progress in Polymer Science. Dr. Ginzburg is a co-editor of a book, "Theory and modeling of nanocomposites" (published by Springer Nature in 2020), and is currently working on another edited book, "Handbook of Coarse-Grained and Multiscale Modeling of Soft Matter: From the Fundamentals to Scientific and Industrial Applications". He has been elected Fellow of the American Physical Society (2014) and awarded the Dow Core R&D Excellence in Science award (2015). His main research interests are polymer glass transition and polymer statistical physics.