COMPUTATIONAL RESEARCH in BOSTON and BEYOND SEMINAR

Math, Methods, and Models for Data-Driven Rheology

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ABSTRACT:

While data-driven tools and techniques have revolutionized much of the scientific and engineering landscape, they have yet to make a substantial impact in the field of rheology. Rheological data sets are at once too scarce and too diverse to enable traditional machine learning approaches — their scarcity a reflection of the time- and material-intensive nature of bulk rheometry, and their diversity a product of the many rheometric protocols and tools used to characterize the mechanical behavior of complex fluids. The success of data-driven rheology depends on our ability to simultaneously employ different types of experimental data in a unified manner, a notable weakness of many common machine learning approaches. In this talk, I will present frameworks that bring together rheological data, and demonstrate their role in designing data-driven tools for modeling and analyzing complex fluids. Among these is a new mathematical construction for asymptotic nonlinearities in simple shear flows, called Medium Amplitude Parallel Superposition (MAPS) rheology. MAPS reveals both a common embedding for many previously disconnected data sets and a new class of data-rich experiments. After discussing the applications of this new rheological data embedding within machine learning frameworks for model identification and material health monitoring, we will develop a new data-driven modeling framework for complex fluids in arbitrarily strong flows. This scientific machine learning framework combines a universal approximator with a frame-invariant viscoelastic constitutive equation, allowing rheologists to train admissible models using laboratory-accessible data. By construction, this framework is highly extensible, and trained models may be deployed scalably in computational fluid dynamic workflows, enabling rapid design of engineering systems involving complex fluids.

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