DFD20-2020-002815

Abstract for an Invited Paper
for the DFD20 Meeting of
the American Physical Society

Designing complex fluids

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A small step away from Newtonian fluid behavior creates an explosion in the range of possibilities. Non-Newtonian fluids can achieve diverse design objectives, but the complexity introduces challenges. This talk will describe these challenges and our contributions to address them. At the continuum-level, careful choice of rheological model descriptions can enable target setting for rheological properties agnostic to formulation and structure. Dimensionless groups also provide a route for microstructure-agnostic understanding, as will be described with yield-stress fluid droplet impact and splashing with applications in wildland fire suppression. At the material-level, flipping structure-to-rheology knowledge to consider the rheology-to-structure inverse problem reveals design strategies. For example, with extensible yield-stress fluids this design-thinking led to the formulation of new direct-write 3D printing inks with unprecedented printing capabilities due to engineered extensibility. This developing design paradigm is applicable to a broad range of applications and material classes and illuminates exciting future research needs at the intersection of continuum- and material-level fluid physics.