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Data-Driven Physics-Informed Constitutive Meta-Modeling of Complex Fluids, Comprehensive Framework and Applications[1] MOHAMMADAMIN MAHMOUDABADBOZCHELOU, SAFA JAMALI, Northeastern University, MARCO CAGGIONI, SETAREH SHAHSAVARI, HARTT WILLIAM, Procter and Gamble Company, NEU AND PG COLLABORATION — We present a Multi-Fidelity Neural Network (MFNN) architecture for data-driven constitutive meta-modelling of complex fluids and compare its rheological predictions with those of a simple Deep Neural Network (DNN) and experimental measurements. The framework allows for inclusion of underlying physics in form of synthetic data used in training of the “low fidelity” network. Generation of these low-fidelity data points here are done using the underlying rheological constitutive models. The high-fidelity network in contrast is trained on limited experimentally measured data. The MFNN is found to be capable of successfully predicting the steady state shear viscosity of a multi-component complex fluid consisting of several different colloidal particle, worm-like micelles and other aromatic particles over a wide range of applied shear rates based on fluid’s primary constituting components. We discuss the role of constitutive model used in data generation on overall performance of the MFNN algorithm. Furthermore, rheological predictions were made for the same system with respect to experiment temperature, salinity of the mixture, and sample aging. We show that by incorporating the appropriate physical intuition into the neural network, the MFNN algorithm captures the role of temperature, the salt level added to the mixture, as well as aging within and outside the range of training data parameters. In contrast, a purely data-driven DNN is consistently found to predict erroneous rheological behavior.

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