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Ensemble-based Data Assimilation Methods for Viscoelastic Material Rheometry during Bubble Collapse[1] JEAN-SEBASTIEN SPRATT, MAURO RODRIGUEZ, KEVIN SCHMIDMAYER, TIM COLONIUS, California Institute of Technology — We examine ensemble-based data assimilation methods for viscoelastic material rheometry, where observation of the radius versus time of a collapsing spherical cavitation bubble is used, together with a physical model for the bubble dynamics, to infer the surrounding material's mechanical properties. Such ensemble-based stochastic methods are attractive for this type of problem, as they fully capture the nonlinear dynamics while keeping computational costs low given the large number of state variables. The ensemble Kalman filter (EnKF), iterative ensemble Kalman smoother (IEnKS), and a hybrid ensemble-based 4D-Var (En4D-Var) method are compared. These are first validated against simulated data with known parameters, and then applied to experimental measurements in water and Polyacrylamide gel (Estrada et. al. 2018, J Mech Phys Solids 112). We show that the IEnKS and En4D-Var improve on the results of the EnKF as expected for this problem, and outperform existing viscoelastic material characterization methods by achieving comparable or better estimation with reduced computational cost. Each method demonstrates particular advantages, the IEnKS being less expensive and better suited for higher frequency data, and the En4D-Var more robust for sparse data sets spanning longer time.

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