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Application of Koopman theory and dynamic mode decomposition to the analysis of nonlinear bubble dynamics ANDREW J. GIBSON, XIN YEE, MICHAEL L. CALVISI, University of Colorado, Colorado Springs — Volume and shape oscillations of gas bubbles in liquids form a central area of study in multiphase fluids, with important applications to intravenous drug delivery, contrast-enhanced ultrasound imaging, and cavitation-induced flow instabilities and damage in turbomachinery. In this study, we use emerging tools from Koopman theory to analyze an extension of the Rayleigh-Plesset equation governing spherical bubble oscillations and their parametrically-driven nonspherical shape modes. In particular, we apply the dynamic mode decomposition (DMD) and the Hankel alternative view of Koopman (HAVOK) analysis to numerically-generated time series. These methods can extract coherent spatio-temporal structures from data and provide a globally linear representation of strongly nonlinear periodic and even chaotic dynamics. Such a Koopman embedding allows for future state prediction and admits the application of classical control techniques, including optimal control. While the resulting framework is applied to simulated data, it may be equally applied to experimental measurements of encapsulated microbubbles or other systems. The issues of multi-scale dynamics and sampling methods are also explored.

Michael L. Calvisi
University of Colorado, Colorado Springs

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