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The role of elasticity on chaotic dynamics: insights from mechanics, immunology, ecology, and rheology

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Abstract-

Elasticity is commonly associated with regular oscillations, which are prevalent in various systems at different scales. However, chaotic oscillations are rarely connected to elasticity. While overdamped chaotic systems have received significant attention, there has been limited exploration of elasticity-driven systems. In this study, we investigate the influence of elasticity on the dynamics of chaotic systems by examining diverse models derived from mechanics, immunology, ecology, and rheology. Through numerical MATLAB simulations obtained by using an ode15s solver, we observe that elasticity profoundly alters the chaotic dynamics of these systems. As a result, we term the underlying equations as the elastic-Lorenz equations. Specifically, we extensively analyze a viscoelastic fluid confined within a closed-loop thermosyphon, considering general heat flux, to demonstrate the impact of the viscoelastic parameter on the model’s chaotic behavior. Our findings build upon prior research on the asymptotic behavior of this model by incorporating the presence of a viscoelastic fluid. The results highlight the non-trivial and non-monotonic role of elasticity in understanding the control, or lack thereof, of chaotic behavior across different scales.

Index Terms- chaotic behavior; nonlinear dynamics; viscoelastic fluids; Lorenz-equations

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