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Singular Longitudinal Waves in Nonlinear Viscoelastic Liquids
PREDHIMAN KAW, SANAT TIWARI, AMITA DAS, ABHIJIT SEN, Institute for Plasma Research — Many fluid materials with strong correlations and memory possess properties which can be described by hydrodynamic equations with viscoelastic transport coefficients, namely, equations of generalized hydrodynamics (Frenkel). Examples of such materials are strongly coupled dusty plasmas, strongly dense astrophysical plasmas, complex fluids, colloidal suspensions, polymeric liquids, blood flowing in arteries etc. We examine the generalized hydrodynamic equations for longitudinal disturbances in the limit of large memory relaxation time. Here longitudinal disturbances propagate as shearless elastic waves and the nonlinear effects arise dominantly through inertial terms. For small amplitude waves, we carry out a reductive perturbation expansion and show that the nonlinear disturbances are described by the Hunter-Saxton equation, an equation with a dual Hamiltonian structure and an infinite number of conservation laws. Nonlinear propagating step like solutions leading to "shock waves of zero strength" are the novel solutions of this equation. For arbitrary amplitudes, exact equations are solved with a stationarity ansatz somewhat different from the standard moving frame ansatz. Exact cusp like solutions with an integrable singularity in the energy like integral, are found.

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