

ASYMPTOTIC DYNAMICS OF AN EXTENSIBLE BEAM MODEL WITH NONLOCAL STRUCTURAL DAMPING

ABSTRACT. We investigate the long-time behavior of an extensible beam equation with nonlocal structural damping driven by fractional powers of the Laplace operator. The model extends several well-known beam equations by incorporating both a nonlinear extensibility term and a possibly degenerate nonlocal damping mechanism depending on the instantaneous energy of the system. Such equations arise naturally in the mathematical modeling of vibrating elastic structures and present substantial analytical difficulties due to the nonlocal and nonlinear character of the dissipation.

We consider the evolution problem

$$u_{tt} + \Delta^2 u - M \left(\int_{\Omega} |(-\Delta)^{\sigma/2} u|^2 dx \right) (-\Delta)^{\sigma} u + \left(\int_{\Omega} |(-\Delta)^{\delta/2} u_t|^2 dx \right)^{\rho/2} (-\Delta)^{\delta} u_t + f(u) = 0,$$

subject to simply supported boundary conditions. The analysis combines energy methods, the Faedo–Galerkin approximation, semigroup theory, and techniques from the theory of infinite-dimensional dynamical systems. The principal contributions are:

- (1) well-posedness of weak and strong solutions for the nonlocal beam model;
 - (2) generation of a dissipative dynamical system and existence of compact global attractors;
 - (3) upper semicontinuity of the family of attractors with respect to the damping parameter;
 - (4) finite fractal dimension, additional regularity, and existence of T -discrete exponential attractor in the linear damping case.
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