Nonlinear vibration of an elastic soft string: large amplitude and large mechanical curvature

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Abstract

Mechanical nonlinear vibration of slender structures, such as beams, strings, rods, plates and even shells occurs extensively in many areas, spanning from aerospace, automobile, cranes, ships, offshore platforms, bridges to MEMS/NEMS. In the present study, the nonlinear vibration of an elastic string with large amplitude and large curvature has been systematically investigated. Firstly, the mechanics model of the string undergoing strong geometric deformation is built based on the Hamilton principle. The nonlinear mode shape function was used to discretize the partial differential equation into ordinary differential equation. The modified complex normal form (CNFM) and numerical method are used to calculate the critical parameters of the string vibration, including the time history diagram, configuration, total length and fundamental frequency. It is shown that the calculation results from these two methods are close, which are different with those from the linear equation model. The numerical results are also validated by our experiment, and they take excellent agreement. These analyses may be helpful to engineer some soft materials, and can also provide insight on the design of elementary structures in sensors, actuators and resonators, etc.

Keywords: **Large amplitude; Large mechanical curvature; Nonlinear mode shape; Vibration configuration; Fundamental frequency**