Localization phenomena in weakly coupled chains of nonlinear oscillators

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Abstract

Many engineering applications make use of frictional damping to dissipate energy. In particular, dry friction is commonly used as a cheap and convenient solution even in very hostile environments. Friction-induced vibrations are experienced in many systems, such us friction brakes or hip joint endoprostheses. We study a chain of friction-excited oscillators with nearest-neighbor elastic coupling. The excitation is provided by a moving belt which moves at a certain velocity, while friction has an exponentially decaying friction law. It is shown that in a certain range of driving velocities, multiple stable spatially localized solutions exist whose dynamical behavior (i.e. periodic or chaotic) depends on the number of masses involved in the vibration. In the bifurcation diagram, in certain range of the governing parameters, these spatially localized states can arrange into two entwined trajectories linking localized solutions at different energy levels and giving birth to the classical snaking bifurcation pattern. To the best of our knowledge, in model systems for friction-induced vibrations, snaking bifurcations have never been investigated even though the emergence of snaking could be well expected, with all the necessary ingredients like flutter instability and bi-stability already known to exist, as observed in ball joints or brake squeal. Contrary to the classical Anderson localization phenomenon, here the underlying linear system is perfectly homogeneous and localization is solely triggered by the friction nonlinearity. The system also shows the possibility that stick-slip front solutions can traverse the frictional interface and with a propagation velocity, which depends on the governing parameter of the model and on the linear/nonlinear coupling among the nodes. A detailed analysis of the vibration shape and of the energy content of the localized solutions is conducted to show similarities and differences with the classical snaking phenomenon.

Keywords

friction induced vibrations, localized states, front propagation, multi-stability