MECHANICAL ENGINEERING STUDENT SEMINAR

Thursday, December 8 2022 at 13:00, Dan and Betty Kahn Building, Auditorium 1.

The mechanical behavior of a chain of bistable springs on an elastic foundation

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Bistable springs are mechanical elements that can support the same external load in two different equilibrium configurations. This results in a non-monotonous force-displacement relation characterized by two branches of positive stiffness separated by a branch of negative stiffness. Arrays of bistable elements have been studied extensively in the last two decades as their behavior is relevant to a wide range of physical phenomena and engineering applications, from soft robotics to multi-stable metamaterials.

Here, we discuss an important model that has been largely overlooked, namely a chain of bistable elements that is supported by an elastic foundation. This model may provide important insights to the analysis of 2-D arrays of bistable elements, promote the development of a new class of composite-like metamaterials, and enhance existing applications that use multi-stable structures. In addition, the model is relevant to biological materials that are composed of proteins with compactly folded domains within a hierarchical structure, such as spider silk, muscle tissue, and biopolymers. In this talk, we introduce a mathematical model that is analyzed analytically, based on approximations, and numerically. Special focus is put on the overall force-displacement relation, and important insights regarding the sequence of phase-transition events are obtained. We show that these are directly related to the celebrated Lucas and Fibonacci sequences, and that stability of equilibrium configurations is associated to the relevant metal mean and in particular cases to the golden ratio. Finally, we find that the sequence of transition can be ordered or disordered, depending on a non-dimensional quantity that characterizes the system.

Note: the seminar will be given in English

Seminars Coordinator: Assoc. Prof. Matthew Suss.