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NONLINEAR DYNAMICS OF SHELL BUCKLING: ADVANCES IN THEORY AND EXPERIMENTS

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ABSTRACT

Two classic challenges of shell buckling are the sphere under uniform external pressure and the axially compressed cylinder. These two well-defined archetypal examples have been widely studied over many years to understand their notorious imperfection sensitivity. They are used here to illustrate two new advances based on rigorous concepts of nonlinear dynamics. Note that throughout this paper the shells will always be assumed to have initial geometrical imperfections that are departures of the middle surface from the geometry of the perfect shell.

First, we describe new ideas in the non-destructive laboratory probing of a progressively loaded shell. These allow a laboratory assessment of its decreasing energy barrier against the random dynamic disturbances of a real-world environment. Spheres and cylinders have been studied, and for the former theoretical and experimental results of this 'shock sensitivity' are in excellent agreement. Generically encountered bifurcations that might interfere with the probing process are carefully examined.

Second, we address the response of a spherical shell to a dynamical step in its pressure loading, modelling perhaps a nearby explosive blast. Accurate nonlinear dynamical simulations illustrate how the initial overall breathing oscillations slowly transfer their energy to a localized buckling mode. We show that there is no unique lowest buckling threshold in this dynamical system, since trajectories can repeatedly come close to the centre manifold of the unstable energy-barrier solution.

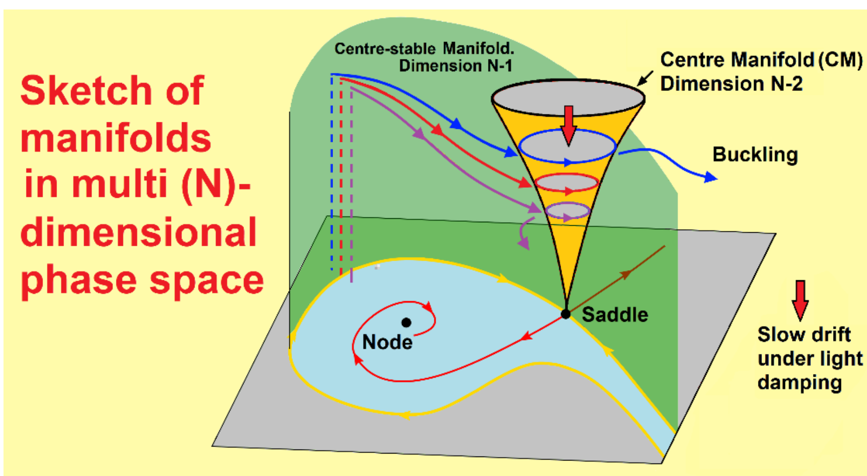

Figure 1: Manifold features of collapse under step loading

Keywords: Shell buckling, Laboratory techniques, Energy barrier, Dynamic loading

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