

Nordmark map and the problem of large-amplitude chaos in an impact oscillator

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Abstract: It has long been known that impacting mechanical systems exhibit sudden onset of large amplitude chaotic oscillation close to grazing. In 1991, Nordmark offered a plausible explanation by showing that the discrete-time map obtained for such systems is piecewise smooth, with a square root term in the right hand side. It was understood that this 'square root singularity' causes the abrupt onset of chaos at grazing. However, bifurcation diagram of the Nordmark map exhibits a gradual increase in the size of the chaotic attractor following grazing, though experimental investigations exhibited an abrupt onset of a large-amplitude chaotic oscillation that lasted for a short range of the parameter. This was called a narrow band of chaos. Evidently, this characteristic of the chaotic orbit is not adequately captured by the Nordmark map. In this paper we probe this question by numerically computing the Poincare map of the system and by analytically computing the corresponding Nordmark map. We find that the two maps differ significantly away from the grazing point. Parts of the attractor lie in regions of phase space where the two maps differ substantially. That is why the classical Nordmark map does not provide a good model to probe this phenomenon.

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