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Grazing-induced bifurcations in impact oscillators with elastic and rigid constraints

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Abstract

This paper investigates differences between the grazing-induced bifurcations in impact oscillators with one-sided elastic and rigid constraints by a path-following (continuation) method. The grazing bifurcations are computed and classified for both oscillators. Two-parameter smooth (period-doubling, saddle-node) and non-smooth (grazing) bifurcations are analyzed. Frequency response curves including bifurcation points are determined for different values of stiffness ratio and restitution of energy coefficient. As the stiffness ratio increases, the constraint changes from elastic to rigid and the bifurcation structure varies correspondingly. For the first time our numerical results presented in [17] and in the current work show that for the impact oscillators with one-sided elastic constraint, the smooth (period-doubling, saddle-node) bifurcations approach the non-smooth (grazing) bifurcations as the stiffness ratio increases. However, for the impact oscillators with one-sided rigid constraint, there is no smooth bifurcations near the non-smooth (grazing) bifurcation points. Basins of attraction, computed by our newly developed Matlab-based computational suite ABESPOL [5], complement our study.

Keywords: non-smooth systems, impact oscillators, discontinuity-induced bifurcations, grazing bifurcations, hysteresis, path following

1. Introduction

Impact oscillators have been widely studied as they are archetypes for non-smooth dynamical systems and because they have many engineering applications such as rotating machinery, car suspension systems, cutting processes, and others [13, 28, 32, 35]. There are two different approaches to impact modelling, namely by using rigid and elastic constraints. The rigid impacts are usually modelled by the coefficient

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