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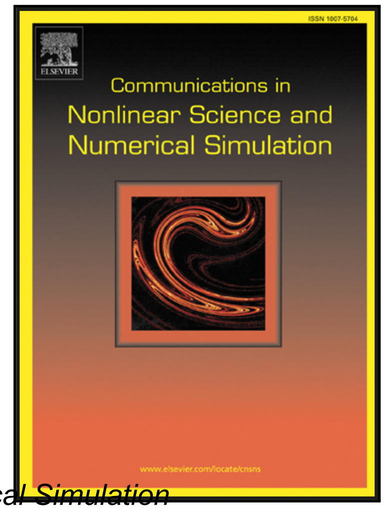

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Mixed-mode oscillations in a three-store calcium dynamics model

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Abstract

Calcium ions are important in cell process, which control cell functions. Many models on calcium oscillation have been proposed. Most of existing literature analyzed calcium oscillations using numerical methods, and found rich dynamical behaviours. In this paper, we explore a further study on an established three-store model, which contains endoplasmic reticulum (ER), mitochondria and calcium binding proteins. We conduct bifurcation analysis to identify two Hopf bifurcations, and apply normal form theory to study their stability and show that one of them is supercritical while the other is subcritical. Further, we transform the model into a slow-fast system, and then apply the geometrical singular perturbation theory to investigate the mechanism of generating slow-fast motions. The study reveals that the mechanism of generating the slow-fast oscillating behaviour in the three-store calcium model for certain parameter values is due to the relative fast change in the free calcium in cytosol, and relative slow changes in the free calcium in mitochondria and in the bounded Ca^{2+} binding sites on the cytosolic proteins. A further parametric study may provide some useful information for controlling harmful effect, by adjusting the amount of calcium in a human body. Numerical simulations are present to demonstrate the correct analytical predictions.

Keywords: Calcium dynamics model, stability, Hopf bifurcation, limit cycle, normal form, GSPM, relaxation oscillation, fast-slow motion, mixed-mode oscillation.

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