

Bifurcation Analysis of Periodic Traveling Wave Solutions in Excitable Reaction-Diffusion Systems

In this talk, I will show the existence and stability of periodic traveling waves (PTWs) in two-variable excitable reaction-diffusion systems. We introduce a system of reaction-diffusion equations to mimic the excitability of cardiac cells. Our results show two types of bifurcations in the periodic traveling waves. The Eckhaus and Hopf bifurcations are two basic bifurcations in the PTWs. There are two families of PTWs: fast and slow. The first one is stable in the case of the standard FitzHugh-Nagumo excitable system. However, we observe that it becomes unstable in our model and bifurcates to an oscillating wave. We explain this phenomenon by numerically calculating the essential spectra of the periodic traveling waves. In addition, the standard FitzHugh-Nagumo model cannot capture the irregular action potentials of sufficiently large periods in a one-parameter family of solutions. Motivated by this, we propose a modified FitzHugh-Nagumo reaction-diffusion system by changing its recovery kinetics. We find that the PTWs of sufficiently large periods cross the stability boundary. Moreover, we observe a reasonable agreement between the direct PDE simulations and the solutions in the traveling wave ODEs. In two dimensions, we study the spiral wave instability that agrees with the waves observed in cellular activity.

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Dr. Mohammad Osman Gani is currently working as a Professor in the Department of Mathematics at Jahangirnagar University, Savar, Dhaka. He has also been a visiting researcher/research promoter in the Meiji Institute for Advanced Study of Mathematical Sciences (MIMS), Meiji University, Tokyo, Japan since April 2015. He obtained his B. Sc. (Hons.), M. Sc. and M. Phil. degrees in Mathematics from the Jahangirnagar University in 1998, 1999 and 2010 respectively. In 2015, he received his Ph. D. degree in Mathematical Sciences from the Meiji Institute for Advanced Study of Mathematical Sciences under Graduate School of Advanced Mathematical Sciences, Meiji University, Tokyo, Japan under a very prestigious scholarship, Global Center of Excellence Scholarship funded by JSPS, Japan. His Ph. D. thesis is mainly concerned with the bifurcation analysis of nonlinear systems through mathematical modeling, analysis and numerical simulation.

Dr. Gani presented his research works in many international conferences (about 70) held in different countries. He has published several articles in peer-reviewed international scientific journals (Publisher: Elsevier, Springer Nature, Easiam, Hindawi, AIP, etc.) (<https://scholar.google.com/citations?user=5tdORG8AAAAJ&hl=en>). He has a research group in nonlinear systems (Applied Computational Mathematics Group) with the BSc/MSc/MPhil/PhD research students and faculty members in his own Department.

