INDIAN INSTITUTE OF TECHNOLOGY GUWAHATI
SHORT ABSTRACT OF THESIS

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SHORT ABSTRACT

This work is concerned with the High Order Compact (HOC) simulation of spiral waves in excitable media in general and study of spiral wave dynamics in particular. An existing unconditionally stable, O($h^4, (\Delta t)^2$) implicit HOC scheme for the two dimensional convection-diffusion equations is reconstructed to discretize some of very well-known models of pattern formation in excitable media, notable amongst them are the Barkley and the FitzHugh-Nagumo (FHN) models. In the process it removes the debilitating effects of the frequently used lower order accurate schemes, notably Euler's explicit scheme to accurately resolve the underlying physiological processes. The discrepancies of explicit schemes are explained through the concept of implicit reaction, dispersion and diffusion by carrying out a thorough analysis of corresponding modified differential equation. Contrary to the usual practice of using state variables solely to explore the dynamics of spiral waves, the spiral wave tip is used as a major tool to study the same. Our study reveals that while the use of the tip leads to accurate prediction of the dynamics, many a time, sole use of the state variables bring about misleading conclusions.

The simulations of spiral waves from our numerical computations are found to be extremely close to the experimental and the available benchmark results in the existing literature. In the process, fourth order accurate approximations to the periodic boundary conditions are derived and used to study the effect of zero flux and periodic boundary conditions on the spiral wave patterns resulting from the Barkley and FHN models in excitable media. Further, the effect of an obstacle on the dynamics of periodic rotating spiral waves is studied, where it is seen to change the trajectory of spiral tip which eventually settles into periodic motion. The reconstructed HOC scheme is then employed to the Oregonator model to study the effect of straining on the stable rotating spiral wave, which is seen to generate a host of complex patterns in three broad regimes: no break up, transitional and break up regimes; these regimes are different from the ones predicted in literature earlier. Finally a dual-purpose implicit, unconditionally stable HOC scheme is developed to discretize the 3D unsteady R-D equations, which is seen to resolve both 3D reaction-diffusion and convection-diffusion equations with equal ease, and could go a long way in simulating scroll waves in excitable media.