INDIAN INSTITUTE OF TECHNOLOGY GUWAHATI
SHORT ABSTRACT OF THESIS

Name of the Student	:	Parvej Khan
Roll Number	:	196122019
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Name of Thesis Supervisor(s)	:	Prof. Sumana Dutta
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SHORT ABSTRACT

Self-organization and the dynamics of rotating spiral waves have captured the interest of numerous researchers within the realm of nonlinear dynamics over recent decades. Various biological systems, such as the human heart and chicken retina, exhibit the presence of spiral waves.

Irregular cardiac rhythm due to spiral wave activity brings great interest in the control and elimination of this kind of spirals from the system. One of the best laboratory model to study the dynamics of cardiac waves is the Belousov-Zhabotinsky (BZ) reaction-diffusion system. In this thesis, we report the experimental and numerical works carried out on individual spirals, as well as on their collective dynamics.

Chapter 1 is a brief introduction of the field of "Nonlinear Dynamics" and pattern formation. The historical development of oscillatory chemical reactions and the Belousov-Zhabotinsky (BZ) reaction has been introduced. The formation of excitable chemical waves as spirals and scrolls and their importance in the context of studying cardiac wave dynamics are outlined. Chapter 2 briefs about the common methodologies used for our experiments and computer simulation. The main findings of our works are reported from Chapter 3 onwards. In Chapter 3, we modified a model developed from the established FKN mechanism of the BZ reaction to study the variation of the spiral wave properties with the explicit concentration of hydrogen ions. We then studied the effect of mild concentration gradients on spiral wave dynamics in our experimental setup in chapter 4, we also demonstrated how these results corroborate with our modified model. From Chapter 5 onwards, we began examining collective spiral wave dynamics in our system. In chapter 5, we revealed how the counter and corotating pinned spirals synchronize and how they differ from each other. Chapter 6 describes the collective phenomena of pinned spirals arranged in a square network, where we report the formation of clusters and chimera of oscillators. Chapter 7 establishes the importance of communication in the synchronization process in a chemical reaction-diffusion system; the observation being motivated by Huygen's well-known Pendulum sympathy experiment, but new in a chemical system. Lastly, Chapter 8 concludes with our results, observations, answered and unanswered questions and propose future direction.