Seminar

Institute for Plasma Research

Title : A study of the dynamics of delay coupled nonlinear oscillators and some model applications

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Time : 10.30 AM

Venue : Seminar Hall, IPR

Abstract :

A network of coupled nonlinear oscillators can display a wide spectrum of collective behavior ranging from synchronization to spatio-temporal chaos, and has therefore served as a useful paradigm to represent collective phenomena in a variety of applications in physical, chemical, biological as well as social sciences. A few fascinating applications among these are in semiconductor lasers, nanomechanical oscillators, and neural oscillator models. Motivated by the amazing complexities exhibited by these seemingly simple oscillator networks, we explore their dynamics when the interaction between the interacting units is not instantaneous but time-delayed as is the case with most real systems. Arising from a variety of reasons, the presence of time delay introduces significant changes in the collective behavior of oscillator networks by influencing the onset thresholds or parametric domain of various collective regimes such as amplitude death and phase-locked states. In the present work, the time delay is shown to introduce very distinct effects depending on the internal details of the network. In the three model systems studied here, the delay affects the (i) network's geometric frustration, (ii) multisensory perception, and (iii) robustness of the network. In the first problem, time delay effects on the collective dynamics of geometrically frustrated networks of phase oscillators are investigated. A systematic quantification of the frustration of some prototypical timedelayed networks is made and a universal scaling behavior is found in its variation with time delay. The results relate to the dynamics of vertebrate segmentation clock which is widely modeled by the delayed coupling theory. The next study aims to provide a dynamical understanding of the multisensory information processing involved in perception through a simple coupled phase oscillator based model. The study focuses on the effect of lag between the onset of auditory and visual stimuli on audio-visual integration. Such a lag is captured by the time-delay parameter in our model. The extent of multisensory integration is quantified by the degree of synchronization of the dynamical system represented by its order parameter and the results show a remarkable qualitative agreement with the experimental observations. An extension of the model has been proposed to incorporate the spatial aspects of multisensory processing into the model. The final model study addresses the effect of time delay on the robustness of the collective dynamics of a coupled-oscillator network against deterioration, such as due to some elements turning non-self-oscillatory, which can be interpreted as aging of the system. We find that the presence of time delay hastens the aging of the system. Among the possible biological applications of this model system are neurodegenerative diseases that are characterized by progressive neuron fall out. Our studies taken together highlight the important consequences of time-delayed interactions on the collective dynamics of oscillator networks with a range of relevant potential implications in real life applications.