Complexity Science Group Seminar

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Science A 121

Dynamical Quorum Sensing and Synchronization in Populations of Excitable and Oscillatory Catalytic Particles

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From the periodic firing of neurons to the flashing of fireflies, the synchronization of rhythmic activity plays a vital role in the functioning of biological systems. Synchronization often occurs by global coupling, where each oscillator is connected to every other oscillator through a common mean field. A distinctly different type of transition to synchronized oscillatory behavior is observed in suspensions of yeast cells. Relaxation experiments demonstrate that slightly below a critical cell density the system is made up of a collection of quiescent cells, whereas slightly above this density the cells oscillate in nearly complete synchrony. This type of transition is much like quorum-sensing transitions in bacteria populations, where each member of a population undergoes a sudden change in behavior with a supercritical increase in the concentration of a signaling molecule (autoinducer) in the extra-cellular solution. We have studied large, heterogeneous populations of discrete chemical oscillators (~100,000) to characterize the two different types of density-dependent transitions to synchronized oscillatory behavior. For different chemical exchange rates between the oscillators and the surrounding solution, we find with increasing oscillator density (1) the gradual synchronization of oscillatory activity or (2) the sudden "switching on" of synchronized oscillatory activity. We have also studied spatially distributed groups of excitable particles that diffusively exchange activator and inhibitor species with the surrounding solution. All particles are nonoscillatory when separated from the other particles; however, spatiotemporal oscillations spontaneously appear in groups above a critical size.

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Everyone is welcome!

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