S N BOSE NATIONAL CENTRE
FOR BASIC SCIENCES
Block JD, Sector III, Salt Lake, Kolkata 700 106

DEPARTMENTAL SEMINAR

Physics of Complex Systems

16th July,2026 **3.00 PM** **FERMION**

SPEAKER

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TITLE OF THE TALK

Changing Degree of Orientational Relaxation Restructures Collective Motion in Polar Active Matter

ABSTRACT

In this talk, I will introduce a Langevin formulation of Vicsek-like active particles in which particle orientations evolve through finite-rate relaxation toward the local mean direction. This framework combines the local consensus mechanism of the Vicsek model with the continuous orientational dynamics of the XY model. Using large-scale numerical simulations, I will present the nonequilibrium phase diagram as a function of activity and alignment rate. As the alignment strength increases, the system undergoes a rich sequence of transitions, evolving from a homogeneous isotropic state to polar bands, then to a striking cross-sea phase characterized by intersecting bands, followed by a homogeneous polar state, and finally a micro-clustered regime. Over a broad range of parameters, the isotropic-to-polar transition is strongly first order, as evidenced by Binder cumulants and bimodal distributions of the local polarization and density, revealing the coexistence of gas-like and liquid-like regions. Near the onset of collective motion, the characteristic band size increases with activity but exhibits a non-monotonic dependence on the alignment rate. A key advantage of the Langevin formulation is that it naturally enables the derivation of continuum hydrodynamic equations through the Fokker–Planck formalism. I will show that this hydrodynamic theory successfully captures the phase behavior observed in simulations, including the emergence of the cross-sea phase. These results demonstrate that finite-time orientational relaxation acts as an important control parameter that qualitatively reshapes the collective behavior of polar active matter.

HOST FACULTY

Dr. Urna Basu, Associate Professor
DEPT. OF PHYSICS OF COMPLEX SYSTEMS

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