Dynamical Response of Random Quantum Systems

Invited Talk 3

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The complexity in the dynamics of many real-world systems having multiple types of dynamics or heterogeneous interactions can be understood by modeling them on multiplex networks. In such systems, the nonlinearity in dynamics, heterogeneity in time scales and complex nature of interactions can lead to many interesting and complex emergent states. While such systems can have directional couplings, majority of the studies on multiplex networks are with bidirectional interlayer couplings. In this talk, we consider a multiplex network with three layers of nonlinear oscillators where the interlayer interactions are represented by unidirectional feedback coupling. We report how this type of directionality in coupling can lead to relay synchronization in the two indirectly connected layers of interacting systems, through the middle relay layer. Moreover, we find amplification of oscillations in the response layers that can be controlled by tuning the strength of interlayer coupling or the dynamical time scale of the drive layer. With nonidentical parameters between the drive and response layers, the response layers get completely synchronized, with a functional relation with the drive, indicating generalized synchronization between the drive and response networks. This model can be applied to various systems like neuronal networks, power grids etc where synchronous oscillations can be generated and controlled in remote networks by tuning the directional coupling and dynamics of a common network of similar oscillators.

Reference

[1] S. R. Jain and P. Gaspard, Dynamical response and time correlation functions in random quantum systems, Annals Phys. **474**, 169922 (2025)