DY 28: Dynamics of Multilayer Networks I (Focus Session SOE/DY/BP) (joint session SOE/DY/BP)

Recently, multilayer networks have been suggested to offer a better representation of the topology and dynamics of real-world systems in comparison with isolated one-layer structures. The prime objective of multiplex networks is to explore multiple levels of interactions where functions of one layer get affected by the properties of other layers. One of the most promising applications of the multilayer approach is the study of the brain, or technological interdependent systems, i.e., those systems in which the correct functioning of one of them strongly depends on the status of the others. The purpose of this focus session is to bring together researchers working on multilayer networks and to share recent ideas and results in the field. (The sessions Dynamics of Multilayer Networks I + II have been organized by Anna Zakharova and Sarika Jalan.)

Time: Wednesday 9:30–12:00 Location: H17

Topical Talk DY 28.1 Wed 9:30 H17

Inhibition induced explosive synchronization in multiplex network — •Sarika Jalan — Complex Systems Lab, IIT Indore, Indore 453552

To date, explosive synchronization (ES) is shown to be originated from either degree-frequency correlation or inertia of phase oscillators. Of late, it has been shown that ES can be induced in a network by adaptively controlled phase oscillators. We show that ES can occur in any network by appropriately multiplexing it with another layer. We devise an approach which leads to the occurrence of ES with hysteresis loop in a network upon its multiplexing with a negatively coupled (or inhibitory) layer. We discuss the impact of various structural properties of positively coupled (or excitatory) and inhibitory layer along with the strength of multiplexing in gaining control over the induced ES transition. This investigation is a step forward in highlighting the importance of multiplex framework not only in bringing novel phenomena which are not possible in an isolated network but also in providing more structural control over the induced phenomena.

Topical Talk DY 28.2 Wed 10:00 H17

Percolation on multi-layer networks — •Filippo Radicchi — Indiana University, Bloomington, Indiana, United States

In this talk, I will review some of my recent papers about percolation on multi-layer networks. I will first illustrate a theoretical approach consisting in a system of heuristic equations able to approximate the phase diagram of the ordinary percolation model for arbitrary multilayer networks. Second, I will introduce and characterize the redundant percolation model, a genuine model for multi-layer networks where the addition of new layers boosts system robustness by creating redundant interdependencies among layers. Third, I will generalize the problem of optimal percolation from single-layer to multi-layer networks, and present several algorithms for finding approximate solutions to the problem. Finally, I will present a large-deviation approach to ordinary percolation able to shed light on the importance of fluctuations in the study of percolation on real-world multi-layer networks.

15 min. break

Topical Talk DY 28.3 Wed 10:45 H17

Mean field phase synchronization across multilayer networks in chimera states — •Ralph Gregor Andrzejak[1], Giulia Ruzzene[1], Kaspar Schindler[2], Eckehard Schöll[3], and Anna Zakharova[3] — [1]Dept. of Information and Communication Technologies, Univ. Pompeu Fabra, Barcelona, Spain — [2]Dept. of Neurology, Sleep-Wake-Epilepsy-Center, Inselspital, Univ. Bern, Switzerland — [3]Inst. für Theoretische Physik, Technische Univ. Berlin, Germany

Chimera states are an intriguing interplay of synchronous and asynchronous motion in networks of coupled oscillators. While chimera states were traditionally studied in one-layer networks, recent work studies interactions of chimera states across coupled layers in multilayer networks. We here review our recent work in which we applied different types of couplings between pairs of networks that individually show chimera states when there is no coupling between them. We show that these couplings across network layers can lead to generalized synchronization [1] and phase synchronization [2] between networks, while both layers continue to exhibit distinct chimera states. We show that these synchronization phenomena are in close analogy to those found for low-dimensional chaotic dynamics.

References: [1] Andrzejak, R. G., Ruzzene, G., & Malvestio, I. (2017). Generalized synchronization between chimera states. Chaos, 27(5), 053114.

[2] Andrzejak, R. G., Ruzzene, G., Malvestio, I., Schindler, K., Schöll, E., & Zakharova, A. (2018). Mean field phase synchronization between chimera states. Chaos, 28(9), 091101.

DY 28.4 Wed 11:15 H17

Weak multiplexing induces coherence resonance — •Nadezhda Semenova[1,2] and Anna Zakharova[3] — [1]Department of Physics, Saratov State University, Saratov, Russia — [2]FEMTO-ST / Optics Dept., Univ. Bourgogne Franche-Comté, Besançon Cedex, France — [3]Institut für Theoretische Physik, Technische Universität Berlin, Berlin, Germany

Using the model of a FitzHugh-Nagumo system in the excitable regime, we study the impact of multiplexing on coherence resonance in a two-layer network [1]. We show that multiplexing allows for the control of the noise-induced dynamics. In particular, we find that multiplexing induces coherence resonance in networks that do not demonstrate this phenomenon in isolation. Examples are provided by deterministic networks and networks where the strength of interaction between the elements is not optimal for coherence resonance. In both cases, we show that the control strategy based on multiplexing can be successfully applied even for weak coupling between the layers. Moreover, for the case of deterministic networks, we obtain a counter-intuitive result: the multiplex-induced coherence resonance in the layer which is deterministic in isolation manifests itself even more strongly than that in the noisy layer.

[1] N. Semenova, A. Zakharova, Weak multiplexing induces coherence resonance, Chaos 28, 051104 (2018)

Topical Talk DY 28.5 Wed 11:30 H17

Relay synchronization in multiplex networks — •Inmaculada Leyva[1,2], Irene Sendina-Nadal[1,2], Ricardo Sevilla-Escoboza[3], and Victor Vera-Avila[3] — [1]Complex Systems Group & GISC, Universidad Rey Juan Carlos, Madrid, Spain — [2]Center for Biomedical Technology, Universidad Politécnica de Madrid, Madrid, Spain — [3]Centro Univ. de los Lagos, Universidad de Guadalajara, Jalisco, Mexico

The relay synchronization is observed when two dynamical units synchronize despite not being directly linked, due to the intermediation of a relay mismatched unit. In our work we have extended the concept of relay synchronization to the case of a multiplex network, showing that the intermediation of a relay layer can lead to inter-layer synchronization of a set of paired layers, both topologically and dynamically different from the transmitter. The phenomenon can be extended to indefinitely higher order relay configurations, provided a mirror symmetry is preserved in the multiplex. The coherent state is very robust to changes in the dynamics, topology, and even to strong multiplex disconnection.Our results provide a new path for starting the study of the role of symmetries in setting long distance coherence in real systems, specially in brain networks, where remote synchronization is of outstanding relevance for coordination between remote cortical areas.