

## **Network and Complex Systems**

Introduction to networks, empirical study of real world networks: Social networks, Technological Networks, Biological networks, Neural Networks, and Information networks; Basic concepts in graph theory, Network representation, Adjacency matrix and edge lists, weighted networks, directed networks, bipartite networks, planar networks, degree, paths and connectivity, graph Laplacian; Characterization of and measures on networks, degree centrality, degree distribution, Katz centrality, hubs and authorities, between-ness centrality, clustering coefficient, Modularity, homophily and assortative mixing. Analytical and computational tools in networks; Representation of network with gephi software package.

Random networks, properties of random networks; Small world networks: Watts-Stogartz model, properties and real world examples; Scale free networks: Barabasi-Albert model, theoretical approaches, characteristics of power law behavior in scale free networks. Examples from citation network, cellular network, internet etc.

Dynamical processes on networks, microscopic approaches to dynamical phenomena, master equation, mean field solutions; Disease spreading on networks, Basic compartmental models like: SIS, SIR and SEIR. Epidemics spreading on static and adaptive networks, with examples from SARS and H1N1; Sexual contact networks and HIV.

Resilience and robustness of networks, Percolation phenomena and phase transitions, percolation on complex networks; damage and resilience in networks, coupled networks and targeted attacks, cascading failures in network.