INTERPLAY BETWEEN STRUCTURAL RANDOMNESS, COMPOSITE DISORDER, AND ELECTRICAL RESPONSE: RESONANCES AND TRANSIENT DELAYS IN COMPLEX IMPEDANCE NETWORKS

By

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Complex impedance networks have been investigated to study electrical and optical properties of disordered inhomogeneous media. So far, some are well understood, for example, the resonance and relaxation properties in low-dimensional structures with conductivity (bond) disorder, as well as on the complete graph.

In this Master Thesis, we study the interplay between structural and conductivity (composite) disorder and the collective electrical response in random network models. Three random network models: small-world network, scale-free network and random geometric graph, are utilized here. Each of them could mimic certain properties of real-world networks. We also employ binary link disorder, which is applicable to any graph (random L-C, RL-C, R-C, or more complicated composite circuits). By translating the problem of time-dependent electrical response (resonance and transient relaxation) in binary random composite networks to the framework of generalized eigenvalues, we study and analyze the scaling behavior of resonances in these structures. Mainly, we focus on two important variables, the density of resonances and number of resonances per node. Numerical results show that by controlling the density of shortcuts (topological randomness) and/or the composite ratio of the binary links (conductivity disorder), one can effectively shape resonance landscapes, or suppress long transient delays in the corresponding random impedance networks. Those results could help understand intrinsic signal propagation properties of different real-world networks, e.g. nanowire networks and neuronal networks.