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Geometrical Self-Assembly of Networks with Large Simplicial Complexes

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Structured networks representing a variety of complex systems, from functional materials [1] and brain activity patterns [2] to online social graphs [3], exhibit a hidden structure that can be attributed to the occurrence of significant simplicial complexes and the emergent hyperbolicity [4]. Q-analysis based on the algebraic topology of graphs can decipher this complex architecture by identifying elementary simplexes beyond nodes and links (triangles, tetrahedrons, and higher order cliques), and revealing the ways that they combine into a particular mesoscopic complex. To understand how such hidden geometries of networks can emerge, we have recently devised a model of geometrical self-assembly of pre-formatted groups of nodes, which are described by simplexes of different sizes [5]. In the model, the geometric compatibility of the attaching simplex with the suitable binding site on the growing network plays a decisive role in addition to the chemical affinity of the system towards adding a number of new nodes. In this lecture, we will describe the model's rules and parameters; then we will demonstrate how different structures are generated by varying the related parameters (see online demo: http://suki.ipb.ac.rs/ggraph/) and distinguish them by determining the appropriate algebraic-topology measures.

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