論文の内容の要旨

論文題目　Topology Dynamics and Collective Fluctuation Behavior in Complex Networks with Preferential Linking
(優先的リンキングを有する複雑ネットワークにおけるトポロジーダイナミクスと協同的揺動挙動)

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（本文）Complex systems are the center of our life nowadays, which pervade all of science, from neurobiology to statistical physics. The most basic issues of complex systems are structural topology: how does one characterize the topology of a complex system? Are there any unifying principles underlying their topology? The studies on the topology of the complex networks are an important movement towards research on complex systems.

First, we study the evolution of the topology of a bipartite network with rewiring dynamics and preferential attachment. The models for the degree distribution of the bipartite network with rewiring dynamics and preferential attachment are categorized into three versions, which are named as a two steps version model (TSV model), a one step version-I model (OSV-I model), and a one step version-II model (OSV-II model). we derive an exact solution for the TSV model and that for the OSV-II model. Furthermore, we show that the evolution of the topology of the bipartite network with rewiring dynamics is globally asymptotically stable.

An important characteristic of the structural topology is “community structure”, which motivates us to construct a model for the degree distribution of a multi-community bipartite network with rewiring dynamics and preferential attachment. The network consists of many interconnected communities, each of which holds a bipartite graph. We show that the degree distribution of the multi-community bipartite network model is equivalent to that in the TSV model.

The topology of some real-world networks evolves not only through rewiring but also through growing of the nodes with time. We construct a model for the degree distribution of a multi-community bipartite network with both rewiring and growing dynamics as well as with preferential attachment. We also show that the degree distribution of the model is equivalent to that of a one-community model that has been analyzed by Réka Albert, Albert-László Barabási and others.

From the perspective of nonlinear dynamics, we would also like to understand how an enormous network of interacting dynamical systems behaves. In such a complex network system, we define a preferential flow that represents a preferential linking among the nodes. The dynamics of one node could be described as a city-population system, a macroeconomic system or, a transportation system. What kind of collective behavior will those nodes have, given their individual dynamics and structural topology? Based on a theoretical analysis, a hidden feedback mechanism has been identified in such a complex network system, which has been illustrated in a macroeconomic network and a city-population network. The real-world data is also used to consider the feedback mechanism. By the hidden feedback mechanism, the observation data can be utilized to directly judge whether the system of each node is a positive feedback system or a negative feedback system even without knowing its dynamical model.