Pattern Formation in Unsynchronizable Complex Networks

Xingang Wang[1,2] and Choy Heng Lai[3,2]

[1]*Temasek Laboratories, National University of Singapore, 117508 Singapore*

[2]*Beijing-Hong Kong-Singapore Joint Centre for Nonlinear & Complex Systems (Singapore), National University of Singapore, Kent Ridge, 119260 Singapore*

[3]*Department of Physics, National University of Singapore, 117542 Singapore*

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Abstract

Pattern formation and evolution in unsynchronizable complex networks is investigated. Due to the asymmetric topology, the synchronous patterns formed in complex networks are irregular and unstationary. For coupling strength immediately out of the synchronizable region, the typical phenomenon is on-off intermittency where the system dynamics switching between the unique state of global synchronization and the various states of partial synchronization. The patterns appeared in this case are marked by the coexistence of a giant cluster, which comprises most of the nodes, and a few number of small synchronous clusters. Pattern evolution in this case is characterized by the attracting and emitting processes of the small clusters from the giant cluster. For coupling strength slightly away from the synchronizable region, the giant cluster disappears and the pattern is composed by a large number of clusters of heterogeneous size distribution, and the system dynamics is characterized by the simultaneously integrating and separating operations among all the clusters. The dynamical origins and statistical properties about the unstationary patterns are investigated, where a number of scalings are newly revealed. More remarkably, it is found that the active nodes, which depart from the giant cluster more frequently, are bifurcation dependent. To be specific, nearby the long-wave bifurcation point they are the lower-degree nodes which are more likely to be broken away from the giant cluster, while nearby the short-wave bifurcation they are the high-degree nodes. We hope these findings could give some insights to the transition process of network synchronization, and provide some implications to the practical cases where systems maintain their normal functions only under the unsynchronizable condition.

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