第154回

附属社会創造数学センター主催
学術変革領域研究（A）「マルチモ−ダルECM」共催

HMMCセミナー

Date： 2024年8月2日（金）16：30～18：00

Speaker： Riccardo Muolo

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Place： 北海道大学 電子科学研究所
中央キャンパス総合研究棟2号館5階 講義室

Style: 対面とオンラインのハイブリット開催

オンラインのみ要事前登録
オンライン参加のお申込みは下記URLからお願いします。

https://zoom.us/meeting/register/tJIsd-6orTosHtwQzUo54N6emP28dLo0GVK9

Title： Introduction to the theory of higher−order interactions
and topological signals: effects on synchronization
dynamics and Turing pattern formation

※当日、体調のすぐれない方は対面で出席はご遠慮願います。

Introduction to the theory of higher-order interactions and topological signals:

effects on synchronization dynamics and Turing pattern formation

Riccardo Muolo (東京工業大学)

Joint work with Hiroya Nakao (東京工業大学), Shigefumi Hata (鹿児島大学), Iván León (University of Cantabria, Spain), Ginestra Bianconi & Runyue Wang (Queen Mary University of London, UK), Timoteo Carletti (Université de Namur, Belgium) and Lorenzo Giambagli (University of Florence, Italy)

Networks are powerful tools in the modeling of complex systems, but they may not capture the right interactions when multiple units are involved simultaneously. Such many-body interactions are encoded by higher-order structures which can be thought as extensions of networks [1]. The most general form is a hypergraph, in which interactions of any order can coexist without any constraint. Over the last years, higher-order structures have been the focus of great excitement, since this novel framework has enormous potential for applications. Moreover, particular interest has been directed towards the analysis of topological signals, i.e., state variables defined not only on the nodes, but also on links, triangles and higher-order structures, which can be coupled together when the higher-order structure is a simplicial complex [2].

In this seminar I will introduce higher-order interactions and their effects on nonlinear dynamics. It will be divided in two parts: one about higher-order interactions and dynamics on hypergraphs, while the other will be focused on the theory of topological signals. In the first part I will introduce the basics of dynamics on networks and its extension to the case of higher-order interactions, i.e., dynamics on hypergraphs. As an example of the effects that such framework can have on nonlinear dynamics, I will discuss the case of phase reduction [3] and show how the presence of three-body interactions can greatly enrich the dynamics of the simplest possible higher-order Kuramoto-Sakaguchi model [4]. In the second part, after having introduced topological signals on simplicial complexes, I will discuss reaction-diffusion dynamics in such framework and show some recent results regarding Turing theory of pattern formation [5,6] and synchronization dynamics [7,8].

References

[1] Battiston F. et al., Networks beyond pairwise interactions: Structure and dynamics. Phys. Rep., 84: 1-92, 2020.

[2] Bianconi G., Higher-Order Networks: An introduction to simplicial complexes. Cambridge University Press, 2021.

[3] Nakao H., Phase reduction approach to synchronisation of nonlinear oscillators. Cont. Phys., 57(2): 188-214, 2016.

[4] León I., Muolo R., Hata S. and Nakao H., Higher-order interactions induce anomalous transitions to synchrony. Chaos 34, 013105, 2024.

[5] Giambagli, L., Calmon, L., Muolo, R., Carletti, T. and Bianconi, G., Diffusion-driven instability of topological signals coupled by the Dirac operator. Phys. Rev. E, 106:064314, 2022.

[6] Muolo R., Carletti T. and Bianconi G., The three way Dirac operator and dynamical Turing and Dirac induced patterns on nodes and links. Chaos Sol. Frac., 178(114312), 2024.

[7] Carletti T., Giambagli L. and Bianconi G., Global topological synchronization on simplicial and cell complexes. Phys. Rev. Lett., 103(18):187401 2023.

[8] Wang R., Muolo R., Carletti T. and Bianconi, G., Global topological synchronization of weighted simplicial complexes. To appear in Phys. Rev. E (2024).