

LTCC Advanced Course

Title: Topology, geometry and dynamics on higher-order networks

Basic Details:

- Core Audience (1styr or 2nd/3rdyr: app. or pure):
- Course Format (**Extended**: 5 x 2hr lectures)

Course Description:

- Keywords: Higher-order networks, discrete topology, discrete geometry synchronization, dynamical systems, mathematical physics
- Syllabus:
Higher-order networks encode interactions between two or more nodes and are attracting large interest in network theory, machine learning and brain research. This course will introduce fundamental topics in algebraic topology and discrete geometry and mathematical physics in order to discuss recent results on higher-order network dynamics including most relevantly topological synchronization.
Lesson 1:
Higher-order networks and topological signals: a brief introduction.
Introduction to algebraic topology: Homology and cohomology
Lesson 2:
Introduction to algebraic topology: Hodge Laplacians and Dirac operators
Lesson 2:
The topological Dirac equation
Introduction to discrete network geometry: Metric cohomology
Lesson 3:
Topological Synchronization: The Topological Kuramoto model and Dirac synchronization
Lesson 4:
Topological Global Synchronization.
Lesson 5:
Information theory of network geometry. Sheafs as gauge fields.
- Recommended reading: Provided Lecture Notes
- Additional Optional reading: Bianconi, G., 2021. *Higher-order networks*. Cambridge University Press. References to research articles provided in the course.
- Prerequisites: Some basic knowledge of algebra and differential equations

Format:

- No of discussion/problem sheets: 4
- Electronic lecture notes: will be available during the course
- Necessary support facilities:

Lecturer Details:

- Lecturer: Prof. Ginestra Bianconi

- Lecturer home institution: Queen Mary University of London
- Lecturer e-mail: g.bianconi@qmul.ac.uk