

## Theoretical foundations for statistical network analysis

This six-month programme brought together branches of pure mathematics - specifically probability and combinatorics – and applied mathematics and statistics. It started in July 2016 with a 5-day workshop which showcased recent developments connecting the concept of graph limits with nonparametric network models, particularly focusing on the current problem of networks with strong heterogeneity. The workshop was attended by over 120 researchers, and coincided with the announcement of multiple participants as winners of the 2016 George Pólya Prize in Combinatorics.

Follow-on workshops in July and August focused on problems in computation and network data analysis, respectively. Organisers announced the establishment of the European Cooperation for Statistics of Network Data Science ([COSTNET](#)), a major European initiative to promote cross-disciplinary collaboration in this important area.

In early November, an [Open for Business Day](#) co-organised with the Turing Gateway to Mathematics (TGM) demonstrated the power of mathematics to address problems in energy networks, financial systems, urban systems and social networks. The event attracted more than 30 participants from industry, 35 from universities, and 10 from other public sector or charitable bodies.

A satellite workshop was held at the Royal Society in London in late November. This event highlighted cross-disciplinary influences on network mathematics, ranging from control theory, to topology and graph limits. Over 60 people attended, including from industry and overseas locations.

The closing workshop in mid-December covered networks in time and in situations where multiple interactions exist between vertices. Presented work included new theory to define such processes, and applied contributions pertaining to neuroscience and international relations. The workshop showcased significant innovations in the field, and closed the programme with a future-oriented perspective, identifying several important research questions that remain for statistical analysis of dynamic networks.

In his lecture, Rothschild Visiting Professor Peter Bickel (University of California, Berkeley), highlighted the connections between statistical network analysis and high dimensional data analysis in his lecture, 'From Small Data to Big Data and Back: Statistics and Data Science'. He placed the programme within the broader context of progress being made in modern statistical theory and methods. He shared a personal view of some of the key results from the programme to date, stressing the fundamental role of sparsity in both assisting and hindering the analysis of real networks and their mathematical structure.

The main outputs from the programme thus far include new models and several different techniques for studying networks that have degrees with an unbounded variance; networks which comprise only one portion of the collected data; networks in which there is more than one type of edge; and networks which are dynamic in terms of temporal and process-related evolution over time.