Titles and Abstracts

1. Miranda Sophie Bane, Centre for networks and collective behaviour, University of Bath, UK

Title: The Robustness of Mutualistic Bipartite Networks to Correlated Node Removal

Abstract: The robustness of a bipartite network is a measure of how the network responds the removal of nodes. Removing nodes of one type can have knock on effects for nodes of another type. There is also the potential for effects to cascade through the network, passing back and forth between node types. Extinction models can be used to measure robustness in a bipartite network. Past work has focused on the effect of random extinctions. In this talk I will discuss the effect of correlated extinctions and cascading effects in bipartite networks. Sequential extinction events cause the network to evolve, and different patterns of collapse emerge. The structural integrity of networks may be gradually eroded, may survive until a tipping point is reached, or may suddenly collapse. We will examine the expected patterns of collapse under different models. My work focuses on these phenomena in plant-pollinator networks. By applying novel extinction models to real world plant-pollinator networks I will demonstrate that correlated extinctions have a significant effect on the expected robustness and pattern of collapse. This has implications for the understanding and conservation of pollinator communities which are currently under threat in some parts of the world.

2. Xujin Chen, Academy of Mathematics and Systems Science, Chinese Academy of Sciences, China

Title: Nonatomic Traffic Networks without Braess's Paradox

Abstract: Braess's paradox exposes a counterintuitive phenomenon that when travelers selfishly choose their routes in a network, removing links can improve overall network performance. Under the model of nonatomic selfish routing, we characterize the topologies of k-commodity undirected and directed networks in which Braess's paradox never occurs. Our results generalize Milchtaich's series-parallel characterization [Games Econom. Behav. 57 (2006), 321-346] for the single-commodity undirected case. (Joint work with Zhuo Diao and Xiaodong Hu).

3. George W. A. Constable, University of Zurich, Switzerland

Title: Strength in Numbers: Demographic Noise can Reverse the Direction of Selection

Abstract: Deterministic evolutionary theory predicts that cooperating phenotypes who display costly altruistic behavior will be driven to extinction. Demographic stochasticity - the population-level randomness that emerges when birth, death and interaction events are unpredictable - can profoundly alter the dynamics of a system. I will describe how this effect can be exploited by altruistic phenotypes to turn the

tide of selection in their favor. The results I will present hold for a general class of mathematical models of competing phenotypes that can modify their environment. Phenotypes that pay a reproductive cost to modify their environment and increase the global carrying capacity can be stochastically selected for, where they would otherwise be deterministically disfavored. The mechanism will be illustrated with a model of public good production, where phenotypes who pay a metabolic cost to produce a common pool resource can be selected for in a stochastic setting, and thus the dilemma of cooperation alleviated.

4. Jonathan Dawes, Bath Institute for Mathematical Innovation, Centre for Networks and Collective Behaviour, and Department of Mathematical Sciences, University of Bath, UK

Title: Are the UN Sustainable Development Goals Self-consistent and Mutually Achievable?

Abstract: On 18 September 2015 the United Nations General Assembly adopted a document with the title *Transforming our world: the 2030 Agenda for Sustainable Development* which sets out a plan of action to shape global development for the period 2015 - 2030 following on from the Millennium Development Goals. The focus of the 2030 Agenda is a set of seventeen Sustainable Development Goals (SDGs).

Compared to the Millennium Development Goals, the SDGs have a much broader reach, and consequently raise competing issues, for example the promotion of both agricultural development and the preservation of biodiversity. One direct response to the 2030 Agenda was a report coordinated by the International Council for Science (ICSU), in partnership with the International Social Science Council (ISSC) which sets out a detailed commentary on the SDGs and the linkages between them.

Taking this ICSU-ISSC commentary as a starting point for a more quantitative analysis of the network of SDGs we show that the SDGs are not self-consistent, but, through a targeted distribution of effort, they are mutually achievable.

5. Jiu-Gang Dong, Department of Mathematics, Harbin Institute of Technology, China

Title: On Flocks Influenced by Closest Neighbors

Abstract: We prove, both for continuous time and discrete time, results establishing convergence to flocking in a model in which each agent is influenced by only a few closest neighbors. We show unconditional convergence to flocking when this number of closest neighbors is at least half of the population and, otherwise, conditional convergence. That is, convergence to flocking provided the initial positions and velocities satisfy an explicit constraint. We also show that the proportion of neighbors necessary for unconditional convergence, one half, is sharp. This is a joint work with Prof. Felipe Cucker.

6. Dick James, Centre for Networks and Collective Behaviour, University of Bath, UK

Title: Temporal Networks of Tool-using Birds

Abstract: I am interested in trying to understand whether and how temporal network data can help us understand some of the biology of social animals. I will illustrate this via two separate studies of tool-using birds. Tool-use is seen in only a tiny fraction of species, so it provokes many questions, including how it evolved and how it develops in young animals. The first study species, the New Caledonian crow, is well-known for its ability to make and use tools to aid extraction of certain foods from trees. The second, the Hawaiian crow, is a critically endangered species which survives only in captivity. It was recently discovered that Hawaiian crows are also proficient tool-users. The data are time-stamped crow associations.

7. Michael David König, University of Zurich, Switzerland

Title: Aggregate Fluctuations in Adaptive Production Networks

Abstract: We study production networks where firms' products can be described by a set of input and output characteristics, and links are formed only if the output characteristics of a seller match the input characteristics of a customer. We introduce a fully endogenous network formation model with monopolistically competitive firms, in which firms exit due to exogenous shocks, or the propagation of shocks through the network. Firms can replace suppliers they have lost due to exit subject to switching costs and search frictions. This enables us to study the impact of shocks on aggregate production in an adaptive network, and we show that depending on the nature of the shocks, adaptivity can make the network more or less stable. We then evaluate the output loss due to the exit of a firm, and apply our model to a large international production network dataset.

8. Amy Middleton, University of Bath, UK

Title: Comparison of Methods for Estimating Distance of Nearest Transmitter in a Cellular Radio Network

Abstract: In a cellular radio network, radio transmitters are ideally placed in locations chosen to optimise network coverage and minimise interference between transmitters. However, for some new technologies it will not be possible to pre-plan or perhaps know the locations of transmitters. We consider a model where the locations of radio transmitters are not pre-planned and instead are chosen independently. In this case, the ability of a transmitter to determine the distance to its nearest neighbour is important for choosing an optimal transmit power that maximises coverage and minimises interference. The ability of transmitters to discover the distance to their nearest neighbour and respond appropriately gives the network of transmitters the property of being self-organising.

I will discuss the model we are using to represent this problem and methods used to estimate the distance to the nearest neighbour. I will compare the accuracy of these methods and discuss future planned work.

9. Kevin Minors, Department of Mathematical Science, University of Bath, UK

Title: Sexual conflict accelerates species invasion

Abstract: We show here how collective motion induced by sexual conflict can greatly enhance the speed of invasion of a species, for example fish, into new territory. We begin by calculating the large time dispersion for a single fish from microscopic run and tumble movement. We then introduce sexual conflict within a pair of fish and show that this can cause an increase in the large time dispersion.

10. Samuel Moore, University of Bath, UK

Title: Two Species Contact Processes

Abstract: Recent work in the physics literature has explored the *two-species contact process* as a model of staged infections. The work has a biological interpretation in terms of host-parasite invasions, for example, when a growing colony of bacteria is under threat from a developing bacteriophage infection. The problem has previously been explored from a deterministic angle, in the setting of the lattice.

In this talk we shall begin by introducing the two-species contact process in generality before moving on to suggest a novel stochastic approach to its analysis using a branching model. In particular we aim to show how a generalisation of the branching process, with a multi type offspring distribution, may be adopted to describe the evolution of the secondary wave of infection directly.

11. Adilson E. Motter, Department of Physics and Astronomy, Northwestern University, Evanston, IL, USA

Title: Asymmetry-Induced Synchronization in Oscillator Networks

Abstract: Synchronization is a paradigm for behavioral uniformity that can emerge from interactions. When the interacting entities are identical and their coupling patterns are also identical, the complete synchronization of the entire network is the state inheriting the system symmetry. As in other systems subject to symmetry breaking, such symmetric states are not always stable. Here, I will present on the discovery of the converse of symmetry breaking—the scenario in which complete synchronization is not stable for identically coupled identical oscillators but becomes stable when, and only when, the oscillator parameters are judiciously tuned to nonidentical values. This corresponds to breaking the symmetry of the system to preserve the symmetry of the state. Aside from demonstrating that diversity can facilitate and even be required for uniformity and consensus, this suggests a mechanism for convergent forms of pattern formation in which initially asymmetric patterns evolve into symmetric ones.

12. Tiago P. Peixoto, Department of Mathematical Sciences and Centre for Networks and Collective Behaviour, University of Bath, UK

Title: Efficient Bayesian inference of multi-scale network structures

Abstract: A principled approach to characterize the hidden structure of networks is to formulate generative models, and then infer their parameters from data. When the desired structure is composed of modules or "communities", a popular choice for this task is the stochastic block model, where nodes are divided into groups, and the placement of edges is conditioned on the group memberships. In this talk, we will

present a nonparametric Bayesian inference framework based on a microcanonical formulation of the stochastic block model. We show how this simple model variation allows simultaneously for two important improvements over more traditional inference approaches: 1. Deeper Bayesian hierarchies, with noninformative priors replaced by sequences of priors and hyperpriors, that not only remove limitations that seriously degrade the inference of large networks, but also reveal structures at multiple scales; 2. A very efficient inference algorithm that scales well not only for networks with a large number of nodes and edges, but also with an unlimited number of groups. We show also how this approach can be used to sample group hierarchies from the posterior distribution, perform model selection, and how it can be easily be generalized to networks with edge covariates and node annotations.

13. Tim Rogers, Centre for Networks and Collective Behaviour, & Department of Mathematical Sciences, University of Bath, UK

Title: Epidemics on Networks: the Risky and the At-risk

Abstract: Which nodes are most vulnerable to an epidemic spreading through a network, and which carry the highest risk of causing a major outbreak if they are the source of the infection? In this talk I will show how these questions can be answered to good approximation using the cavity method. Several curious properties of node vulnerability and risk are explored: some nodes are more vulnerable than others to weaker infections, yet less vulnerable to stronger ones; a node is always more likely to be caught in an outbreak than it is to start one, except when the disease has a deterministic lifetime; the rank order of node risk depends on the details of the distribution of infectious periods.

14. Sudeshna Sinha, Indian Institute of Science Education and Research, India

Title: Dynamics of Rewired Networks

Abstract: We will show how spatio-temporal chaos in networks with strongly chaotic nodal dynamics can be tamed by dynamically changing links. Specifically, we will illustrate the results in examples ranging from neuronal networks to disease spreading models. Further we will show how random links can prevent blow-ups in coupled nonlinear systems suffering from unbounded growth.

15. Li-Ping Wang, Institute of Information Engineering, Chinese Academy of Sciences, China

Title: On Jumped Wenger Graphs

Abstract: In this talk we introduce a new infinite class of bipartite graphs, called jumped Wenger graphs, which are closely related to Wenger graphs. An tight upper bound of the diameter and the exact girth of a jumped Wenger graph $J_m(q, i, j)$ for integers i, j, $1 \leq i < j \leq m + 2$, are determined. In particular, the exact diameter of the jumped Wenger graph $J_m(q, i, j)$ if $(i, j) = (m, m+2), (m+1, m+2)$ or $(m, m+1)$ is also obtained. Furthermore, we obtain the explicit spectrum.

16. Zheng Xie, College of Science, National University of Defense Technology, Changsha, China

Title: Decision and Social Complexity

Abstract: Compared with atoms or stars in physical world, human society is complex, which has a variety of complex structures. Therefore, though scientists have discovered many inherent laws underlying a series of physical phenomena from atomic fusion to star evolution, they know little about the behaviors of human society. Do there also exist inherent rules behind the social complexity? We try to answer this question through two kinds of coupling social behaviors, namely scientific collaboration and citation behaviors. A geometric graph for the coevolution is proposed, and is validated against a data set of papers published in PNAS during 2000-2015. The validation shows the ability to reproduce a range of features observed with citation and coauthorship data combined and separately. The model reveals how the decisions of individuals in networks generate a range of complex behaviors, such as scale-free and small-world, and how pass through the divide between "$1 + 1 = 2$" and "$1 + 1 > 2$". The model can be extended to other social network research, e.g. web-graphs.

17. Qian Yang, Centre for Networks and Collective Behaviour, Department of Mathematical Sciences, University of Bath, UK

Title: Demographic Noise Slows Down Cycles of Dominance

Abstract: We study the phenomenon of cyclic dominance in the paradigmatic Rock–Paper–Scissors model, as occuring in both stochastic individual-based models of finite populations and in the deterministic replicator equations. The mean-field replicator equations are valid in the limit of large populations and, in the presence of mutation and unbalanced payoffs, they exhibit an attracting limit cycle. The period of this cycle depends on the rate of mutation; specifically, the period grows logarithmically as the mutation rate tends to zero. However, this behaviour is not reproduced in stochastic simulations with a fixed finite population size. Instead, demographic noise present in the individual-based model dramatically slows down the progress of the limit cycle, with the typical period growing as the reciprocal of the mutation rate. Here we develop a theory that explains these scaling regimes and delineates them in terms of population size and mutation rate. We identify a further intermediate regime in which we construct a stochastic differential equation model describing the transition between stochastically-dominated and mean-field behaviour.

18. Pan Zhang, The Institute of Theoretical Physics, Chinese Academy of Sciences, China

Title: Spectral Clustering in Networks without Localization Problem

Abstract: Spectral methods are popular in clustering nodes in networks. However, when the network is sparse or noisy, classic spectral methods usually fail to work, due to localization of eigenvectors. In this talk, we introduce a general method to solve the localization problem by learning a regularization matrix from the localized eigenvectors. Using matrix perturbation analysis, we demonstrate that the learned regularizations suppress down the eigenvalues associated with localized eigenvectors

and enable us to recover the informative eigenvectors representing the community structures. We show that our method solves the localization problem and works down to the theoretical detectablity limits in different kinds of synthetic networks. This is in contrast with existing spectral clustering algorithms based on the adjacency matrix, the non-backtracking matrix, Laplacians and those with rank-one regularizations, which perform poorly in the sparse networks with noise.

19. Xiao-Dong Zhang, Shanghai Jiao Tong University, China

Title: The Turán Number of Disjoint Copies of Paths

Abstract: The Turán number of a graph H, $ex(n, H)$, is the maximum number of edges in a simple graph of order n which does not contain H as a subgraph. Let $k \cdot P_3$ denote k disjoint copies of a path on three vertices. In this paper, we determine the value $ex(n, k \cdot P_3)$ and characterize all extremal graphs for all n and k. This extends a result of Bushaw and Kettle [N. Bushaw and N. Kettle, Turán Numbers of multiple and equibipartite forests, Combin. Probab. Comput., 20(2011) 837-853.], which solved the conjecture proposed by Gorgol in [I. Gorgol. Turán numbers for disjoint copies of graphs. *Graphs Combin.*, 27 (2011) 661-667.].