Prof. Dr. Fatihcan M. ATAY

Title of the talk: Time Delays and Cooperative Dynamics on Networks
Abstract: We consider dynamics on finite networks that evolve under a discrete Laplacian operator and in the presence of time delays. The spatial structure naturally invites notions from graph theory into the analysis of the dynamical behavior. We discuss the effects of structure and delays on the dynamics, for both undirected and directed graphs, as well as for discrete and distributed delays. We then extend the results to graphs with time-varying structure. Applications are indicated in the fields of the stability of traffic flow, synchronization of coupled systems, and consensus in distributed computing and social dynamics.

Professor Jacek Banasiak

Title of the talk: Structured populations with fast dynamics – patches and networks
Abstract: We consider structured population models in which the population is subdivided into states according to certain feature of the individuals. We consider various rules allowing individuals to move between the states – it may be physical migration between geographical patches or the change of the genotype by mutations during mitosis. We shall see that depending on the type of the migration rule the models can vary from a system of coupled McKendrick equations to a system of transport equations on a graph. We address the well-posedness of such problems, classical in the first case and more challenging in the second. The main interest, however, will be asymptotic state aggregation that, in the presence of different time scales, allows for a significant simplification of the equations. Interestingly enough, the aggregated equations vary widely, from scalar transport equations to systems of ordinary differential equations. Some aspects of long term dynamics also will be discussed.

Prof. Dr. Mapundi Banda

Title of the talk: Modelling of natural gas flow on networked domains
Abstract: In this talk, we present mathematical analysis, numerical analysis and some scientific computing involved in the study of natural gas flow in networked domains. The flow in the network links is modelled using nonlinear hyperbolic partial differential equations. Firstly, a discussion of well-posedness of coupling conditions at the network junctions will be discussed. To solve the coupling problem at the junction a generalised Riemann problem is solved. Further, a discussion of a numerical analysis of the numerical discretisation of the coupling conditions at the junction will be presented. The computational results will be discussed alongside theoretical results.

Pr. Dikande Alain Moise

Title of the talk: Seismicity of a mechanical model of Earthquake fault with compteting nonlinear elastic and frictional forces
Abstract: Instabilities caused by the stick-slip motion of contact tectonic plates are believed to be responsible for seismic faults favoring the release and propagation of stress accumulated within the plates. As a mechanical process the fault generation can be described by the so-called Burridge- Knopoff (BK) model, consisting of an elastic lithosphere overlying a viscous asthenosphere and a fault of finite width with an upper brittle (i.e. seismic) zone having an elastoplastic response. Mathematically the BK model assumes a periodic network of linearly interacting equal-mass blocks forming the asthenosphere, each block coupled to the upper plate (i.e. the lithosphere) via linear springs and a nonlinear frictional force between the two plates. In this talk we shall discuss the effects of competing elastic and frictional anharmonicities on seismicity of the BK model.

Dr. Kwabena Doku-Amponsah

Title of the talk: LARGE DEVIATION PRINCIPLE FOR EMPIRICAL MEASURES OF MULTITYPE RANDOM NETWORKS
Abstract: In this article we study the stochastic block model also known as the multi-type random networks (MRNs). For the stochastic block model or the MRNs we define the empirical group measure, empirical cooperative measure and the empirical locality measure. We derive for these empirical measures, large deviation principles for the MRNs in the weak topology. As an application, we discuss some possible extension of our main result to process level LDP for the evolutionary and co-evolutionary processes on the MRNs.

Dr. Benedikt Jahnel

Title of the talk: Dynamical Gibbs-non-Gibbs transitions for continuous spin models
Abstract: I will present results on the behaviour of certain random network models in continuous space under time evolution. At time zero, the network can be formulated as an infinite-volume Gibbs measures for hard-core interaction potentials based on superpositions of Poisson point processes. The time-evolution is given by a simple Poisson flip dynamics which independently flips the individual spins. The main results represent first steps into the analysis of non-localities induced into the system by the time evolution, which result in non-Gibbsian behaviour of the evolved model. Finally, I sketch ideas on how to extend this line of research and make a connection to our future collaboration partners.

Prof. Dr. Wolfgang KÖNIG

Title of the talk: Random message routing in highly dense multi-hop networks
Abstract of the talk: We investigate a probabilistic model for routing in a multihop ad-hoc communication network, where each user sends a message to the base station. Messages travel in hops via the other users, used as relays. Their trajectories are chosen at random according to a Gibbs distribution that favours trajectories with low interference, measured in terms of sum of the signal-to-interference ratios for all the hops, and collections of trajectories with little total congestion, measured in terms of the number of pairs of hops arriving at each relay. We derive qualitative properties of this minimizer, like the typical number of hops and the typical length of a hop, and the deviation from the straight line. We encounter and quantify emerging typical pictures in analytic terms in two extreme regimes: (1) in the limit of a large communication area and large distances, and (2) in the limit of a strong interference weight.

Prof. KOFANE

Title of the talk: Scalar and Vector 2D, 3D and 4D Dissipative optical light bullets, Rogue waves in paraxial and nonparaxial optical solitons
Abstract of the talk: The need to transmit more and more information quickly on the web is pushing many laboratories to discover new technologies, to increase the ability of optical fibers to carry digital communications. Driven by this growing desire, research has reached the point where the future high-speed fiber optics could be based on the exploitation of different modes of data transmission, which is based on the kinetic momentum orbital light waves. Therefore, optical fibers could transmit data by means of a kind of vortex of light. It is electromagnetic waves having a polarization and therefore a particular spin, more precisely, an orbital angular momentum. With such waves, one could theoretically increase the rate of optical fibers in the same frequency band. By using signals with orbital angular momentum modes at different wavelengths, Wavelength Division Multiplexing has even been possible.

Assoc. Prof. Dr. Marjeta Kramar FIJAVŽ

Title of the talk: Perturbation methods for differential operators on networks
Abstract of the talk: We present a semigroup approach to different evolutionary processes (such as transport or diffusion) in networks. The processes along the edges are modelled by linear first or second-order differential operators whereby the boundary conditions in the vertices of the network are contained in the domain of the corresponding operator. We use

a result for boundary perturbations of domains of generators developed by Adler-Bombieri-Engel and Hadd-Manzo-Rhandi to show well-posedness of the problem for a very general set of boundary conditions. We can treat also non-compact networks, where some edges are allowed to have infinite length.

Dr Samir EL Mourchid

Title of the talk: On mixing behaviour of chaotic linear dynamical systems.
Abstract of the talk: In our talk we will be interested in chaotic systems. We will try to prove that despite their erratic and unstable behaviours, they are likely to be statistically predictable. For this goal, we use tools from Ergodic theory and Gaussian processes. More precisely, we tackle the problem of the existence of an invariant mixing measure considering its connection with the chaotic behaviour of a linear infinite dimensional system. We first prove an identity characterizing invariant Gaussian measure involving its covariance operator and the infinitesimal generator of the semigroup. This gives an answer to a question raised by Ryszard Rudnicki in one of his inspiring papers. Under suitable conditions, we used the proved identity to give an invariant mixing Gaussian measure as distribution of a Wiener Integral.

Dr. Delio MUGNOLO

Title of the talk: Surgery of quantum graphs: eigenvalues and heat kernels
Abstract of the talk: Quantum graphs are collections of intervals glued at their endpoints in a network-like fashion, along with differential operators acting upon them. We consider elliptic equations associated with these structures: while the eigenvalues of Laplacians may in principle be found as the zeros of a (transcendental) secular equation, this task is hard to pursue. Since a pioneering paper by Nicaise, much attention has been devoted to derive a-priori spectral estimates that only depend on global quantities of combinatorial (like edge connectivity, total edge or vertex number), metric (like total length or diameter) or hybrid (like girth or the Cheeger constant) nature. We well review some recent advances in this field based on simple surgery principles that allow for spectral and heat kernel comparison of two different graphs. This is joint work with Gregory Berkolaiko, James Kennedy and Pavel Kurasov.

Dr. Proscovia Namayanja

Title of the talk: Chaotic dynamics in a transport equation on a network
Abstract of the talk: We show that for a system of transport equations defined on the edges of an infinite network, thesemigroup generated is hypercyclic if and only if the adjacency matrix of the line graph is also hypercyclic. We further show that there is a range of parameters for which a transport equation on an infinite network with no loops is chaotic on a subspace Xe

of the weighted Banach space l_1. We relate these results to the birth-and-death model in [1], [2] (in the publication section above) by showing that when there is no proliferation; the birth-and-death model described by an infinite system of ODEs is also chaotic in the same subspace Xe of l_1.

Dr Jean Medard Tchoukouegno Ngnotchouye

Title of the talk: Multiphase flow models in a network of pipes
Abstract of the talk: This talk deals with various coupling conditions at a junction of a network of connected pipes in which the flow is governed by a multiphase flow model. Each phase of the fluid is assumed to be isentropic with its own sonic speed. For the simulations of the flow for the whole network, one needs to impose some coupling conditions that link the flows at the junction of intersecting pipes. These coupling conditions play a key role in the proof of the well-posedness of the Riemann problem at the junction, which consist of solving the flow equations in each pipe with constant initial conditions in each pipe. We prove the well-posedness of the Riemann problem at the junction using a linearized version of the Lax curves and we simulate the flow for a small network of five pipes and two junctions.

Dr. Savannah Nuwagaba

Title of the talk: The role of non-linear functional response on predator's body size evolution.
Abstract: Predator - prey interactions shape food web structure, the functioning of ecosystems and the response to perturbations. However, the interplay between their ecological and evolutionary dynamics and how these contribute to regulate food web dynamics have received less attention. Using adaptive dynamics, a mathematical tool has been developed to study feedbacks between ecological and evolutionary processes, we investigate the influence of non-linear functional response on the evolution of a predator's body size and allow for polymorphism to show how food webs emerge from a single ancestor through the process of mutation and natural selection. We also allow potential invaders into the coevolving food weds to test how invasion success depends on difference properties and parameters.

Dr. Alex Awasi Opoku

Title of the talk: Interdependent decision making: A view from statistical mechanical window?
Abstract: Interdependent decision making is a common theme in Social Sciences, Econometrics and Marketing. Here the emphasis is on how one's choice for a good or service is influenced by the choices made by the other members of a reference group. In this presentation we will review some of the mathematical models used to understand socioeconomic phenomenon driven

by choices made by individuals in a reference group. Statistical mechanical analogues of some of these models will be discussed.

Dr. Agnes RADL

Title of the talk: Transport processes in networks with scattering ramification nodes
Abstract of the talk: In this talk I will present a transport problem in a network which is modelled by a directed weighted graph. We assume that particles can move along the edges with different velocities. In the vertices the particles are scattered, i.e., they change their velocity. Then they are distributed among the outgoing edges according to the wheights of the edges. Our main interest is in the time asymptotic behaviour of the system. To this end we formulate the problem as an abstract Cauchy problem and then apply semigroup methods.

Prof. Dr. Abdelaziz Rhandi

Title of the talk: Abstract Boundary systems and application to flow in networks with memory
Abstract of the talk: In many cases partial differential equations can be modeled as abstract boundary value problems. Based on the theory of infinite dimensional regular systems we study a class of boundary perturbation problems with distributed and boundary delay terms. As an application we consider a ow in a network with unbounded delays. We prove well-posedness of such equations and analyze the asymptotic stability of solutions.

Associate Professor Ursula SCHARLER

Title of the talk: Ecological Network Analysis applications in ecological and socio-economic systems
Abstract of the talk: I will present an overview of the ecological network analysis (ENA) methodologies that are of importance in ecological and socio-economic systems, and highlight those that are used across both sectors. Some of these methodologies lend themselves for easer interpretation (e.g. pathway analyses) than others (e.g. information theory), and as they essentially describe complex systems, the translation and comparison to known status indicators of for instance ecosystems is often challenging. Furthermore, I will talk on the historical development of verifying models with empirical data, and the challenges that arise for modellers, empirical ecologists, and managers of systems.

Dr. Christian SEIFERT

Title of the talk: Singular diffusion on graphs with "sticky" vertices

Abstract of the talk: We consider singular diffusion on metric graphs, motivated by modelling particles moving in a network according to a "speed measure" which describes the possible locations of the particles as well as the speed the particles can move with. We aim for an analytic description via self-adjoint operators for which we impose suitable coupling conditions at the vertices of the graph, and also classify the couplings leading to self-adjoint generators of positive and submarkovian semigroups that is the corresponding form is a Dirichlet form. We will also explain that these forms describing singular diffusion are indeed traces of Dirichlet forms.

Prof. Dr. Peter STOLLMANN

Title of the talk: Quantitative uncertainty principles and the first non-zero eigenvalue on graphs
Abstract of the talk: We present recent results that show that eigenfunctions of graph laplacians are spread out in space provided the energy is low enough. This result is somewhat surprising, since it has been known for quite a while that unique continuation of eigenfunctions fails for graphs. However, a spectral uncertainty principle can still be applied and gives explicit and uniform estimates that exhibit "the right" geometric features. One important input of independent interest is the spectral geometry on general weighted graphs, in particular universal estimates for the first non–zero eigenvalue of the Laplacian on such graphs. This quantity, also known as the spectral gap is connected to a variety of geometric concepts. Our analysis shows that the spectral bounds obtained are optimal in a certain sense. We expect that the geometric features of these discrete graphs can also be applied to more complex dynamics of the evolution of coupled ode's on metric graphs.

Dr. Conrad Bertrand Tabi

Title of the talk: Nonlinear Patterns and Synchronized States in Neural Networks
Abstract of the talk: We explicitly show the existence of two frequency regimes in a two- dimensional Hindmarsh-Rose neural network. Each of the regimes, through the semi- discrete approximation, is shown to be described by a two- dimensional complex Ginzburg–Landau equation. The modulational instability phenomenon for the two regimes is studied, with consideration given to the coupling intensities among neighboring neurons. Analytical solutions are also investigated, along with their propagation in the two frequency regimes. These waves, depending on the coupling strength, are identified as breathers, impulses and trains of soliton-like structures. Although the waves in two regimes appear in some common regions of parameters, some phase differences are noticed and the global dynamics of the system is highly influenced by the values of the coupling terms. For some val-

ues of such parameters, the high-frequency regime displays modulated trains of waves, while the low-frequency dynamics keeps the original asymmetric character of action potentials. We argue that in a wide range of pathological situations, strong interactions among neurons can be responsible for some pathological states, including schizophrenia and epilepsy.