5^{th} CRITICS Workshop

27-31 August 2018, Cork

Organization Committee:

Chun Xie

Peter Ashwin

Sebastian Wieczorek

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This project has received funding from the European Union's Horizon 2020 research and innovation programme under the Marie Skłodowska-Curie grant agreement No 643073.

1 Workshop Programme

Time	Monday, 27 August	Location: Aula Maxima
08.45-09.25	Registration	
09.25	Opening remarks (Sebastian Wieczorek)	
Chair	Martin Rasmussen	
09.30-10.15	James Gleeson	
10.20-11.05	Edgar Knobloch	
11.10-11.40	Tea/coffee break	
11.40-12.10	Henk Dijkstra	
12.15-12.45	Courtney Quinn	
12.50-15.00	Lunch break	
Chair	Ulrike Feudel	
15.00-15.30	Peter Ditlevsen	
15.35-16.05	Christian Pangerl	
16.10-17.30	Informal Discussions	
17.30-20.00	Welcome Reception at Franciscan Well Brewery	

Time	Tuesday, 28 August	Location: Aula Maxima
09.00-09.30	Registration	
Chair	Kathrin Padberg-Gehle	
09.30-10.15	Philipp Hoevel	
10.20-11.05	Didier Sornette	
11.10-11.40	Tea/coffee break	
11.40-12.10	Ulrike Feudel	
12.15-12.45	Egbert van Nes	
12.50-15.00	Lunch break	
Chair	Jan Sieber	
15.00-15.30	Rafael Obaya	
15.35-16.05	Anna Vanselow	
16.10-17.00	Informal Discussions	
17.00-19.00	Poster Session with music, snack and drinks	

Time	Wednesday, 29 August	Location: Aula Maxima
09.00-09.30	Registration	
Chair	Peter Ditlevsen	
09.30-10.15	John Dearing	
10.20-11.05	Marten Scheffer	
11.10-11.40	Tea/coffee break	
11.40-12.10	Carmen Nunez	
12.15-12.45	Pablo Rodríguez-Sánchez	
12.50-15.00	Lunch break	
15.00	Bus to Kinsale. Departure at UCC Western Gateway Building	
16.00-17.30	Tour of Kinsale	
18.00	Dinner at Fishy Fishy	

Critical Transitions in Complex Systems
This project has received funding from the European Union's Horizon 2020 research and innovation programme under the Marie Skłodowska-Curie grant agreement No 643073.

Time	Thursday, 30 August	Location: Aula Maxima
Chair	Jeroen Lamb	
09.30-10.15	Mike Jeffrey	
10.20-11.05	Chris Jones	
11.10-11.40	Tea/coffee break	
11.40-12.10	Jan Sieber	
12.15-12.45	Paul Ritchie	
12.50-15.00	Lunch break	
Chair	Peter Ashwin	
15.00-16.00	Panel Discussion	
16.00-18:00	CRITICS Steering Committee Meeting (Committee Members only)	

Time	Friday, 31 August	Location: Civil Engineering Building Room CE G10
Chair	Chris Jones	
09.30-10.15	Andrew Keane	
10.20-11.05	Johan Dubbeldam	
11.10-11.40	Tea/coffee break	
11.40-12.10	Sajjad Bakrani	
12.15-12.45	Andreas Amann	
12.50	Closing remarks	
13.00-15.00	Lunch break	

2 Participants

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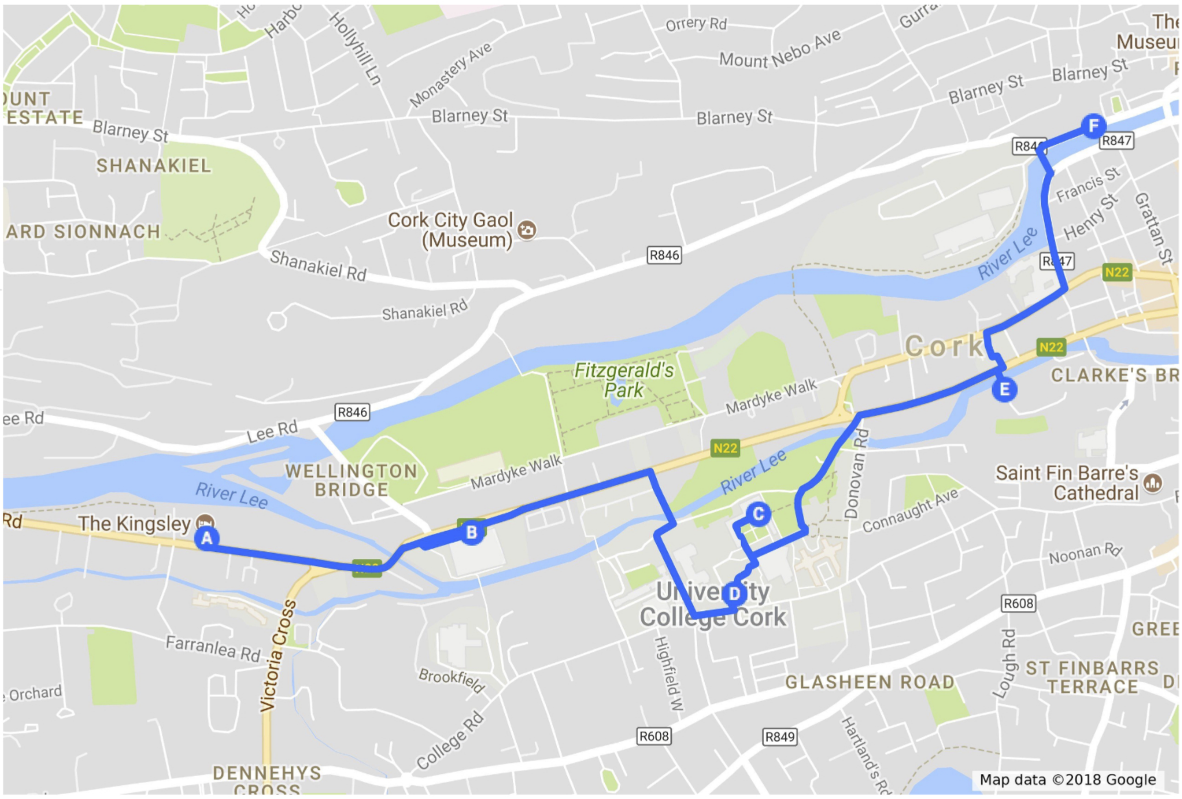
3 Maps



A: The Kingsley, B: UCC Western Gateway Building, C: Aula Maxima, D: UCC Civil Engineering Building, E: The River Lee, F: Franciscan Well Brewery

4 Internet

Participants have two options to access the Internet:

- Wi-Fi eduroam: eduroam (EDUcation ROAMing) is the secure world-wide roaming infrastructure used by affiliated Users and educational facilities to allow their staffs, students and Users to visit other participating institutions and continue to have wireless connectivity. Being part of eduroam allows users to access a wireless network at a visited participating institution simply by using credentials (i.e. username and password) assigned to them by their home institution. More information here if you have an identity from your home institution to access eduroam. https://www.ucc.ie/en/it/services/eduroam/
- Wi-Fi UCC Guests:
  Username: soms-2018-aug
  Password: y9Cbykjb

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5 Invited Talks

Cascade dynamics on networks

James Gleeson
University of Limerick, Ireland

Network models may be applied to describe many complex systems, and in the era of online social networks the study of dynamics on networks is an important branch of computational social science. Cascade dynamics can occur when the state of a node is affected by the states of its neighbours in the network, for example when a Twitter user is inspired to retweet a message that she received from a user she follows, with one event (the retweet) potentially causing further events (retweets by followers of followers) in a chain reaction. In this talk I will review some simple models that can help us understand how social contagion (the spread of cultural fads and the viral diffusion of information) depends upon the structure of the social network and on the dynamics of human behaviour. Although the models are simple enough to allow for mathematical analysis, I will show examples where they can also provide good matches to empirical observations of cascades on social networks.

Pinning and Depinning in Nonautonomous Systems

Edgar Knobloch
Department of Physics, University of California at Berkeley

In this presentation I will describe some recent work on synchronization in nonautonomous systems. I will use the ideas developed in this context to study pinning and depinning of fronts in a nonautonomous Swift-Hohenberg equation, focusing on resonance phenomena and canard solutions that are present when the depinning timescale is comparable to the forcing period. I will conclude with some speculations about the role of nonautonomous forcing on the behavior of pattern-forming systems.

Rise and fall of online topics: understanding dynamic hashtag communities

Philipp Hövel
Department of Applied Mathematics, University College Cork, Ireland
Institute of Theoretical Physics, Technische Universität Berlin, Germany

Social platforms and online media have become a major driving force of public interest and opinion formation with great importance for economics, politics, and beyond. In forums and blogs, billions of threads are discussed every day, covering a broad spectrum of topics. Time-resolved data has become more and more available in recent years. The format of hashtags is particularly convenient for a content-related analysis. As a condensed version of information they characterize topics and discussions.

For their analysis we apply methods from network science and propose novel tools for tracing their dynamics in time-dependent data. We propose (1) a numerical method for dynamic community detection in a co-occurrence networks created from hashtags with time-stamped edges and (2) a modeling framework to better understand underlying mechanisms:

(1) The algorithm is based on static community detection extended by higher-order memory. Our method solves the matching problem of communities detected across several instances of time. The results are robust with respect to temporal fluctuations and instabilities of the static community detection.

(2) As an observable of the dynamics of topics, we consider the size of the communities in time. We find that the distributions of gains and losses are fat-tailed indicating occasional, but large and sudden changes in the usage of hashtags. We propose a mechanistic model that incorporates a ranking with respect to a prestige score, consisting of the size (imitation) and the age (recency) of a community. The model reproduces the observations to good agreement and offers an explanation for the observed ranking dynamics and the resulting bursts.

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A General Framework Reconciling Rational with Inefficient Financial Bubbles and a novel mechanism for financial fubbles (time-varying momentum horizon)

Didier Sornette
ETH Zurich

At odds with the common "rational expectations" framework for bubbles, economists like Hyman Minsky or Charles Kindleberger have put forward the idea that irrational behavior, ambiguous information or certain limits to arbitrage are essential drivers for bubble phenomena and financial crisis. Following this understanding that asset price bubbles are generated by market failures, we developed a mathematical framework for explosive processes that is based on the antagonistic combination of excessive behavior and a crash.

Our framework significantly extends the range of feasible asset price processes during times of financial speculation and frenzy and provides a strong theoretical background for future model design. It will simplify and foster interdisciplinary exchange at the intersection of economics, (mathematical) finance and risk management.

As an example of application of the general framework, building on the notion that bubbles are transient self-fulfilling prophecies created by positive feedback mechanisms, we construct the simplest continuous price process whose expected returns and volatility are functions of momentum only. The momentum itself is measured by a simple continuous moving average of past prices over a given time horizon. We introduce a simple dynamics of the time horizon used by the typical investor, which is motivated by the race of trend-following agents to forerun their competitors. We provide the full set of solutions, which leads to a neat taxonomy for the type of bubbles, i.e., the wild bubble (an hyper-exponential regime where the price explodes stochastically in finite time to infinity), the recurrent bubble (momentum cause transient rallies) and the mild bubble (price dynamics escaping to infinity with exponential of exponential growth). The proposed price generating process generates price dynamics that are in agreement with the main qualitative properties of empirical financial time series. Moreover, it produces realistic regime shifts between non-bubble and bubble regimes. We construct a quasi-likelihood methodology to calibrate the model to empirical financial time series, which is applied to an Internet index and a "brick-and-mortar" index, over the period of the dotcom bubble and its subsequent crash, from Jan. 1998 to Dec. 2002. The Wilks test of nested hypotheses shows a very strong skill in diagnosing the bubble of the Internet index and in disqualifying a bubble in the "brick-and-mortar" index.

Anatomy of a critical transition: Erhai lake, SW China

J.A. Dearing[1*], Rong Wang[2], C.P. Doncaster[3], P.G. Langdon[1]
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Erhai lake is a large lake set in the mountainous Yunnan Province, China, which has undergone eutrophication. Algal blooms were infrequent before 2001 that have since become almost a permanent characteristic. Previous research has termed the change at Erhai from mesotrophic, clear water to eutrophic, turbid conditions as a regime shift, if not a critical transition. This paper reviews the empirical research that aims to understand the processes responsible for the shift and the extent to which the findings map on to theories of resilience and critical transitions. A notable feature of the research is the use of lake sediment analyses, particularly algal fossils (diatoms), to extend the timescale of monitored or other records. The results describe a rapid shift from one ecological state to another brought about by the combined stress of nutrient loading from agriculture and effluent, artificial and climate-driven water level lowering, exotic fish introductions and temperature rise over the previous few decades. The lack of water quality recovery, even as some stresses have declined since 2001, provides evidence of hysteresis and a potential fold bifurcation. Partial reconstruction of the feedback loops and system architecture sheds light on the mechanisms involved at each stage of the eutrophication process - before, during and after the shift. The shift itself is associated with the strengthening of interaction between two positive feedback loops, which weakens after the shift has taken place. Drawing on theories from community ecology and network science, novel approaches show how changes in both the dynamics of diatom communities and the distributions of co-associated diatom species provide leading indicators of structural change in the lake system. As stress increased, compositional disorder increased as weakly competitive species were ousted by keystone species and, in turn, by weedy species. Changes in the skewness and clustering of the distribution of species (nodal) degree reveal losses of structural integrity and resilience prior to the shift. Finally, the paper reviews the usefulness of conventional conceptual models to describe the whole sequence of change in drivers, ecological responses and early warning signals.

Quantifying Systemic resilience of humans and other animals

Marten Scheffer
Wageningen University and Research Centre

All life requires the capacity to recover from challenges that are as inevitable as they are unpredictable. Understanding this resilience is essential for managing the health of humans and livestock. It has long been difficult to quantify resilience directly, forcing practitioners to rely on indirect static indicators of health. However, measurements from wearable electronics and other sources now allow us to analyze the dynamics of physiology and behavior with unsurpassed resolution. The resulting flood of data coincides with the emergence of novel analytical tools for estimating resilience from time series. Such dynamic indicators of resilience may be used to mark the risk of systemic failure across systems ranging from organs to entire organisms.

Hidden nonlinearities of switching

Mike Jeffrey
University of Bristol

In the last few years we have discovered a number of "illusions of noise" induced by the presence of discontinuities (e.g. switches, decisions, jumps in physical constants) in dynamical systems. When a system switches abruptly between two or more modes of behaviour, it can begin evolving along the discontinuity threshold between modes — so-called sliding dynamics. Such behaviour is usually highly robust, but it turns out that the tight constraint of the variables involved in sliding motion can unleash a frustration on other variables that makes them wild and unpredictable. Their erratic variation and sensitivity to modelling assumptions creates the illusion of underlying noise when in fact none is present.

These kinds of behaviour are changing the way we understand the dynamics that occurs at the thresholds between different regimes of behaviour. Most importantly they have implications for our very notion of determinism in systems that can switch between different modes. Hidden dynamics provides a way to open up the sites of discontinuity, and explore how far we can extend determinism. There are limits to predictability of systems as they transition between regimes, and these can manifest as arbitrary pauses in motion, or spurious illusions of noise.

The most simple and striking illusion of noise is called "jitter". If two investors trading stocks in a company seem to reach a steady trading level, jitter can send the company value into unexpected erratic fluctuations. If the supply and demand of a commodity, such as oil, are regulated to a steady level, jitter can cause the commodity price to become volatile and unstable. The basic idea can be applied to mechanical, fluid flow, electronic, or other physical systems.

In this phenomenon the devil really is in the details. A sliding mode is a dynamical solution that evolves perfectly along the threshold where a discontinuity occurs in a set of differential equations. The notion of stability of a system to perturbations at a discontinuity is not a standard one in dynamical systems, so the study of real world non-ideal switching has been a long running challenge. We now understand how the tiniest non-idealities in the description of a discontinuity can manifest themselves as enormous large scale sensitivity. Depending on the application the true system might glide smoothly along the threshold (e.g. in mechanical sticking), or it might chatter along the threshold (e.g. in electronic variable structure control or thermostatic switching). There may be factors of time delay, hysteresis, or stochasticity in the switching process. Any of these can have a huge affect on variable not constrained by the sliding mode, but a combination of Filippov's inclusions, recent piecewise smooth dynamical theory, and singular perturbations, reveal that certain geometry constraints the erratic outcomes.

A single switch or discontinuity is very robust to non-idealities, which is part of the reason why sliding modes have been so successfully applied in electronic and mechanical control, but also in ecology, physiology, and a growing range of life science modelling. Two or more switches or discontinuities, however, become highly unstable to such perturbations, allowing them to vastly affect the outcome. Their effects can be understood within a range of behaviours known as "hidden dynamics" associated with switching. A coincidence of switches creates a sensitivity responsible for erratic or 'jittery' dynamics, which creates the illusion of underlying noise.

Rate-Induced Tipping in Systems of ODEs

Chris Jones
University of North Carolina at Chapel Hill

Rate-induced tipping occurs when a parameter in the system is changed rapidly enough to destabilize a state that would be attracting with frozen parameter values. Results on when this can and cannot occur are well known for scalar equations, but many questions are open for systems of equations due to the higher dimensional phase space. I will give some basic criteria that work for classes of systems that have interest in applications. In particular, a rather neat result holds for monotone systems. I will discuss what this implies for some physical systems arising from climate studies, including a layered radiative atmosphere system and a hurricane model introduced recently by Emmanuel. In the latter example, there are some suggestive implications as to what it would take to trigger or kill a hurricane. This is joint work with Claire Kiers (UNC-CH).

Bifurcations and multi-frequency tipping
in a periodically forced delay differential equation

Andrew Keane
The University of Auckland

We study a delay differential equation comprised of negative feedback and periodic forcing terms - both important ingredients for conceptual climate models. For certain parameter values, we observe in simulations the sudden disappearance of (two-frequency dynamics on) tori. This can be explained by the folding of invariant tori and their associated resonance tongues. It is known that two smooth tori cannot simply meet and merge; they must actually break up in complicated bifurcation scenarios that are organised within so-called Chenciner resonance bubbles.

We conduct a bifurcation analysis of such a resonance bubble in order to understand the dynamics associated with folding tori. Their role as a mechanism for multi-frequency tipping will be discussed.

Weighted multilayer competition fosters structural stability of mutualistic ecosystems

Johan Dubbeldam
Delft University of Technology
This work was done in collaboration with X. Wang, Y. Moreno and T Perron

Though interspecific competition profoundly changes community structure and species coexistence, there is a lack of theory to properly incorporate interspecific competition in mutualistic systems. Here, we develop a framework based on multilayer network theory to incorporate interspecific competition derived from and varied with shared mutualists. Using theoretical and numerical analysis, we show that incorporating competition dramatically alters necessary conditions for the coexistence of mutualistic communities. We suggest a shift from global to local network properties when assessing the effect of network architectures on biodiversity. The framework is applicable to ecological communities where positive and negative interactions coexist or in the face of species loss and species invasion under environmental change.

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6 Contributed Talks

The point of no return for climate action: effects of climate uncertainty and risk tolerance

Henk Dijkstra
Utrecht University

If the Paris Agreement targets are to be met, there may be very few years left for policy makers to start cutting emissions. Here we calculate by what year, at the latest, one has to take action to keep global warming below the 2K target (relative to pre-industrial levels) at the year 2100 with a 67% probability; we call this the point of no return (PNR). Using a novel, stochastic model of CO2 concentration and global mean surface temperature derived from the CMIP5 ensemble simulations, we find that cumulative CO2 emissions from 2015 onwards may not exceed 424 GtC and that the PNR is 2035 for the policy scenario where the share of renewable energy rises by 2% per year. Pushing this increase to 5% per year delays the PNR until 2045. For the 1.5K target, the carbon budget is only 198 GtC and there is no time left before starting to increase the renewable share by 2% per year. If the risk tolerance is tightened to 5%, the PNR is brought forward to 2022 for the 2K target and has been passed already for the 1.5K target. Including substantial negative emissions towards the end of the century delays the PNR from 2035 to 2042 for the 2K target and to 2026 for the 1.5K target. We thus show how the PNR is impacted not only by the temperature target and the speed by which emissions are cut but also by risk tolerance, climate uncertainties and the potential for negative emissions. Sensitivity studies show that the PNR is robust with uncertainties of at most a few years.

Complex Climate Response to Astronomical Forcing: The Middle-Pleistocene Transition in Glacial Cycles and Changes in Frequency Locking

Peter Ditlevsen
University of Copenhagen

Through the past few million years large ice sheets have repeatedly grown and disappeared on the Northern hemisphere. These are the Pleistocene glaciations. They are related to the changing solar heating of the Earth due to changes in Earth's orbit and axis of rotation. The climate response to these changes is highly non-trivial and non-linear, expressing the complex nature of the climate system. Many aspects of glacial cycles still need a convincing explanation, one particular mystery being the change from approximately 40 kyr (kilo year) glacial cycles to approximately 100 kyr cycles around 1 million years ago. This transition is called the middle Pleistocene transition (MPT). Here we review some conceptual models to explain the dynamics of glacial cycles and possible dynamical causes of the MPT. We especially focus on the well studied van del Pol oscillator as a conceptual model for the glacial cycles and propose that the MPT is a result of changes in frequency locking of the climate system to the astronomical forcing. This is compared to a recently presented model that relates the MPT to a transcritical bifurcation in the structure of a generic critical/slow manifold for a fast-slow dynamical system.

Rate-induced tipping of the AMOC in a global oceanic box model

Courtney Quinn
University of Exeter

The Atlantic Meridional Overturning Circulation (AMOC) is an example of a system that has been observed to show multi-stability across the model hierarchy, and one that is of high importance to regional climate projections. Some of the simplest models of the AMOC are box models, which can be traced back to Stommel (1961). Here we present a box model of the global ocean derived from model runs of the FAMOUS intermediate complexity coupled atmosphere-ocean model. While many of the previously proposed box models show that the bifurcation associated with the AMOC "on" state losing stability is a saddle node, for the global oceanic box model we consider here, the

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bifurcation is in fact a subcritical Hopf. This has a number of consequences for the behaviour of the basin of attraction close to bifurcation, including a rapidly shrinking basin due to a homoclinic orbit. We explore changes in the forcing of the system to show that, in principle, rate-induced tipping can occur even for perturbations that do not cross the Hopf bifurcation.

A Girsanov approach to slow parameterising manifolds in the presence of noise

Christian Pangerl
Imperial College London

We consider a three-dimensional slow-fast system with quadratic nonlinearity and additive noise. The associated deterministic system of this stochastic differential equation (SDE) exhibits a periodic orbit and a slow manifold. The deterministic slow manifold can be viewed as an approximate parameterisation of the fast variable of the SDE in terms of the slow variables.

In other words the fast variable of the slow-fast system is approximately "slaved" to the slow variables via the slow manifold. We exploit this fact to obtain a two dimensional reduced model for the original stochastic system, which results in the Hopf-normal form with additive additive. Both, the original-, as well as the reduced system admit ergodic invariant measures describing their respective long-time behaviour. We will show that for a suitable metric on the space of probability measures on phase space the discrepancy between the marginals along the radial component of both invariant measures can be upper bounded by a quantity describing the quality of the parameterisation. However, we can show this only in a parameter regime, which is close to criticality. An important technical tool we use to arrive at this result is Girsanov's theorem, which allows us to modify the SDEs under consideration in a way that preserves the transition probabilities.

Tipping phenomena in typical dynamical systems subjected to parameter drift

Balint Kaszas[1], Ulrike Feudel[2], Tamas Tel[1]
[1]Eötvös University Budapest, Hungary
[2]Carl von Ossietzky University Oldenburg, Germany

Tipping phenomena, i.e. dramatic changes in the possible long-term performance of deterministic systems subjected to parameter drift, are of current interest but have not yet been explored in cases with chaotic internal dynamics. Based on the example of a paradigmatic low-dimensional dissipative system subjected to different scenarios of parameter drifts of non-negligible rates, we show that a number of novel types of tippings can be observed due to the topological complexity underlying general systems. Tippings from and into several coexisting attractors are possible, and one can find fractality-induced tipping, as well as tipping into chaos. Tipping from or through an extended chaotic attractor might lead to random tipping into coexisting regular attractors, and rate-induced tippings appear not abruptly as phase transitions, rather they show up gradually when the rate of the parameter drift is increased. Since systems of arbitrary time-dependence call for ensemble methods, we argue for a probabilistic approach and propose the use of tipping probabilities as a measure of tipping. We numerically determine these quantities and their parameter dependence for all tipping forms discussed.

Global resilience of tropical forests and savannas to critical transitions

Egbert van Nes
Wageningen University and Research

In my talk I will give an overview on some of our work to study on bistability and resilience of tropical forests and savanna's based on satellite data. We have interpreted the multi-modal distribution of tree cover data as alternative stable states. This interpretation is not a proof of bistability as it can also be caused by other mechanisms such as multimodality in conditions. However, we substantiated this interpretation by showing a likely mechanism based on independent satellite data of fire probability. We show a clear effect of tree cover on the probability of fires: the more tree cover the less

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likely they catch fire. This is a positive feedback as fires cause tree mortality. Due to percolation it is also a highly non-linear effect. We show both in a simple and a detailed spatial model that the observed fire patterns can cause bistability. The resilience of both states are evaluated in different ways.

Persistence in monotone skew-product semiflows with applications to non-autonomous Nicholson systems

Rafael Obaya
University of Valladolid, Spain

We give sufficient conditions for the uniform and strict persistence in the case of skew-product semiflows generated by the solutions of non-autonomous families of cooperative systems of ODEs, delay FDEs or parabolic PDEs in terms of the principal spectrum of some associated linear skew-product semiflow, which admit a continuous separation. We apply our results to a noncooperative almost periodic Nicholson system with a patch structure, whose persitence turns out to be equivalent to the persistence of the linearized system along the null solution. This is a join work with Sylvia Novo and Ana Sanz.

Rate-induced transitions in population dynamics

Anna Vanselow[1], Sebastian Wieczorek[2] and Ulrike Feudel[1]
[1]Carl von Ossietzky University Oldenburg, Germany
[2]University College Cork, Ireland

In ecology, critical transitions between alternative stable states of several ecosystems have been a major focus of research during the last decades. The large interest arises from the fact that such transitions can result in i.a. population collapses, dominance changes in communities or even the loss of species. Most of the work devoted to the study of critical transitions in ecology considers environmental conditions to be constant until the ecosystem is in equilibrium. In other words, changes in environmental conditions which are comparably fast or even faster than the internal ecosystem dynamics are neglected. In nature, such variations of environmental conditions are present and have already occurred at unprecedented rates. These fast changes of the environment are possibly too fast to adapt to for certain ecosystems leading to unexpected changes of their current state - called rate-induced transitions. In my talk, I will demonstrate that rate-induced transitions occur in population dynamical models and that they can result in dramatic consequences for the considered ecosystem.

Li-Yorke chaos in nonautonomous Hopf bifurcation

Carmen Nunez
University of Valladolid, Spain

We analyze the characteristics of the global attractor of a type of dissipative nonautonomous dynamical systems in terms of the Sacker and Sell spectrum of its linear part. The model gives rise to a pattern of nonautonomous Hopf bifurcation which can be understood as a generalization of the classical autonomous one. We pay special attention to the dynamics at the bifurcation point, showing the possibility of occurrence of Li-Yorke chaos in the corresponding attractor and hence of a high degree of unpredictability. This a joint work with Rafael Obaya.

Neutral competition and chaos. An example of reproducible research

Pablo Rodríguez-Sánchez
Wageningen University and Research

Have you ever thought of how many lines of scientific code are hidden in researcher's hard drives? Have you ever tried to reproduce a complicated algorithm described only with words on a scientific publication? In this talk, I will use my recently released paper as a case study to briefly review the technical possibilities and difficulties regarding publishing, citing and maintaining scientific code. https://pabrod.github.io/seminar-cork-en.html

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Rate-dependence in shell buckling problems

Jan Sieber
University of Exeter
Joint work with JMT Thompson, JH Hutchinson

The problem of a structure buckling under load is classical and was one motivation for the introduction of bifurcation theory and catastrophy theory into engineering in the 1970's. When studied quasi-statically the buckling problem (of beams, shells, plates) produces bifurcation diagrams that look very much like those involved in other tipping scenarios: at a critical load, the unbuckled stable equilibrium undergoes a transcritical or fold bifurcation. When one considers dynamic loading the picture is very different. There may be many saddles over which escape can occur and the unbuckled branch is only (nearly) neutrally stable since internal damping is close to zero such that the dynamic critical load depends strongly on the rate of loading (even within the range of validity of elastic theory). I will present the case of a nearly perfect shell, loaded with a spatially uniform pressure step and will report some initial observations. Among other things we observe that buckling occurs with a considerable delay after the pressure step.

Searching for UK ecosystem tipping points in a land-surface model

Paul Ritchie
University of Exeter

Here we present results from JULES, a land surface model, analysing the effect of climate sensitivity and CO_2 fertilisation on the UK's land ecosystems. We compare and contrast a number of ecosystem variables at a high spatial resolution over the UK for both current and end of the century climate snapshots, and for CO_2 at present and future levels, resulting in four different configurations.

Having observed significant changes in some ecosystem variables at high spatial resolution we search for tipping point behaviour using coarser transient driving data that spans from 1998 to 2100. We introduce a method to detect and classify tipping point behaviour in time series, assessing how strong a non-linear response is, and what direction it is in. We compare the locations of these tipping points to those found in the climate time series (rainfall and air temperature) to determine if true non-linear behaviour is exhibited, rather than a linear response to climate forcing. We also search for early warning signals of these ecosystem tipping points, to varying success.

Fold bifurcations under external forcing and early warning signals in population dynamics

Flavia Remo
Friedrich-Schiller-Universität Jena
Joint work with T.Jäger and G. Fuhrmann
Talk Cancelled

In this talk, we study the saddle node bifurcation under external forcing that may lead to the formation of strange non-chaotic attractors. We investigate early warning signals such as critical slowing down prior to population collapse and distribution of finite time Lyapunov exponents. We apply our results to the Allee-effect model under quasiperiodic, random or both (hybrid) forcing processes.

CRITICAL Transitions in Complex Systems

This project has received funding from the European Union's Horizon 2020 research and innovation programme under the Marie Skłodowska-Curie grant agreement No 643073.

Invariant Manifolds of a homoclinic orbit in a 4D system with a first integral and a $\mathbb{Z}_2$ symmetry

Sajjad Bakrani
Imperial College London

A homoclinic orbit is an orbit of a dynamical system which joins an equilibrium point to itself. More precisely, a homoclinic orbit lies in the intersection of the stable invariant manifold and the unstable invariant manifold of an equilibrium. These orbits play an important role in understanding the global behavior of a dynamical system. In this talk we describe the dynamics in a small neighborhood of a homoclinic orbit of a particular family of 4D systems of differential equations. In particular we provide necessary and sufficient conditions for the existence of the stable and the unstable invariant manifolds of the homoclinic orbit. We then pay a special attention to the case where these two invariant manifolds intersect.

The Devil is in the Spectrum: The Eigenvalue Distribution of the Discrete Preisach Memory Model

Andreas Amann
University College Cork

The Preisach Model is a generic model for the description of hysteresis. Extreme past events in the input of the model are memorized through a sequence of main extrema, which determine the shape of the observed hysteresis loops.

Here we analytically calculate the full spectrum of an discrete version of the Preisach model, and show that in the infinite dimensional limit it corresponds to an appropriately scaled Devil's staircase function. Further insight is also obtained by analytically constructing the corresponding eigenvectors.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under the Marie Skłodowska-Curie grant agreement No 643073.

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