Contributions from members

The Nonlinear and Complex Physics Group are interested to receive comments and material for future editions of the newsletter. The committee also welcomes suggestions of topics for scientific meetings and other activities that may be of interest to its members. Anyone interested in organising a meeting or who would like to suggest a topic suitable for a meeting are invited to contact the NCPG Chair at e.suckling@reading.ac.uk.

http://www.iop.org/activity/groups/subject/Nonlinear_and_Complex_Physics/index.html
1. Editorial

Welcome to the fifth issue of our Newsletter for the Nonlinear and Complex Physics Group (NCPG). As a group our interests cover a wide range of disciplinary backgrounds, including topics from the quantum, biological and earth sciences through to the astrophysical. Progress is often made in these fields using interdisciplinary approaches and drawing connections between different areas of science concerned with nonlinear phenomena and complexity. The aim of our group is therefore to foster these interests, bringing together researchers across disciplines, as well as to attract undergraduate and graduate students into nonlinear and complex physics.

It’s been another successful and exciting year for our group, in which we’ve hosted and participated in a number of fantastic events! In particular, members of our committee have been involved in organising activities such as discussion workshops on complexity in the biological sciences, energy sector and more. We also hosted our first summer workshop on complexity for school children, which you can read more about in this newsletter. We have awarded a prize to the winner of our student essay competition and of course have our annual Yuletide Lecture to look forward to. You can read about some of our past events and get a glimpse of some of the things to come over the next year in this newsletter.

This year has also seen some changes within the NCPG committee and it is with regret that I announce the departure of Martine Barons and Yong Mao from the committee. In addition our Chair, Tobias Galla, and our Secretary, Jean Boulton, will be stepping down from their positions with immediate effect. Both will remain on the committee as ordinary members, as Mark Hardman steps in as interim Secretary and I as interim Chair until our AGM, which will take place in the first half of next year. The whole committee would like to thank Martine, Yong, Tobias and Jean for their incredible hard work over the last few years. They have been a great asset to the NCPG group and have done a fantastic job of promoting the work of our group and bringing together the wide-ranging communities working within the fields of nonlinear and complex physics. We are grateful to Tobias and Jean for agreeing to continue on as committee members, and to Mark for stepping in during the interim period. We would also like to welcome two new committee members, Matt Garrod (University of Manchester) and Bernd Taschler (University of Warwick), who both join us as student representatives. Matt Garrod was also the winner of the 2014 Student Essay Competition, so congratulations to him for that!

Finally I would like to wish you all a Merry Christmas and Happy New Year! I hope 2015 will be a productive and exciting time for you all. As always we welcome your feedback and suggestions for topics and events of interest so that we can continue to keep the activities of our group relevant to you.

Best wishes,

Emma Suckling (Interim Chair: NCPG)
2. Forthcoming events supported by the NCPG

**OU Energy Conference: Open University, Milton Keynes**  
**4th December 2014**

**Topic:** 2nd Annual Evening Lecture and Reception  
**Venue:** Berrill Lecture Theatre, Open University  
**Time:** 18.00-20.00

Following the success of last year’s event the Open University are pleased to announce their second series of short talks and discussion on the theme of electricity system complexity. The panel from industry, public policy and academia will bring diverse perspectives on the various challenges and emergent threats arising from, or impacting on, the future electricity system. Confirmed speakers include:

Marcelo Masera, European Commission  
Gary Swandells, Smart Grid Consultancy  
George Matthew, Open University

A drinks reception starts at 6.15pm with the talks beginning at 7pm.

Registration is required. Please reply to angela.walters@open.ac.uk by Monday 24th November if you wish to register attendance.

**ICTPI15: The Open University, Milton Keynes**  
**17-19th June 2015**

**Topic:** 15th International Conference on Technology, Policy and Innovation  
**Venue:** The Open University, Milton Keynes

ICTPI’15 conference aims to bring together leading representatives of academic, business, and government sectors worldwide to present and discuss current and future issues of critical importance for using science and technology to foster regional economic development and shared prosperity at home and abroad.

www.ictpi15.info
2014 NCPG Yuletide Complexity Lecture

Speaker: Dr Draga Pihler-Puzović
“Nonlinear physics of viscous fingering”

Tuesday 2nd December 2014, 6.00pm-8.30pm*

Dalton and Joule Suite, Museum of Science & Industry, Liverpool Road, Castlefield, Manchester M3 4FP

An anonymous author once pointed out that classifying problems as linear and non-linear is like classifying things in the Universe as bananas and non-bananas. In this talk we will explore some beautiful and surprising characteristics of nonlinearity through an example in the mechanics of fluids: viscous fingering. If an air bubble displaces a viscous liquid in a narrow gap between two plates, the interface between the bubble and the liquid tends to lose symmetry. This will lead to the formation of interfacial patterns called viscous fingering that are similar to snowflakes and dendrites. We will show how by tinkering with parts of the system (for example, by making the plates elastic), we can discover a surprising range of new phenomena and observe non-linear patterns that can be found nature.

Dr Draga Pihler-Puzovic was born and raised in Belgrade, Serbia, but completed her education in Russia, obtaining her undergraduate degree in Mechanics at the Lomonosov Moscow State University. In 2007 she moved to Cambridge to work on her PhD thesis at the Department of Applied Mathematics and Theoretical Physics (DAMTP) under the supervision of Professor T. J. Pedley, FRS. In January 2011 Dr Pihler-Puzovic came to the University of Manchester as a postdoctoral researcher, becoming a lecturer in the Manchester Centre for Nonlinear Dynamics and the School of Physics in August 2014. Her research combines experiments with mathematical modelling to understand and quantify fundamental phenomena in nonlinear physics that arise in applications ranging from physiological problems to industrially-motivated systems.

* Tea and coffee will be available before the talk, from 6.00pm and there will be a wine reception afterwards, ending around 8.30pm.

If you would like to attend then please contact Emma Suckling before 30th November at: e.suckling@reading.ac.uk
Prof Henry D.I. Abarbanel presented the group’s 2013 Yuletide Lecture with the title: A Physicist’s View of Complexity. His opening challenge was the questions: what is complexity and what is simple? He suggested that the key to understanding such issues is the number of degrees of freedom of a system.

He observed that at the end of the 19th Century phenomena looked complex, because at that time we had no understanding of the issues. Scientists studied the simple systems first – for example: hydrogen spectroscopy before iron. Helium was found in the sun before it was found on Earth based on the emerging understanding from hydrogen spectroscopy.

Professor Abarbanel explained that complex outcomes have their origins in the dynamics of non-linear systems. Furthermore complex outcomes should have underlying physical, biological or other principles. He suggested that today we should understand complex problems by looking for simple representations, not unlike the role played by hydrogen in 19th Century spectroscopy. He observed that Newton’s method for finding the cube roots of unity reveals the beautiful fractal basis of attraction to the three roots. A simple question yields a complex structure. Another example Edwin Colpitts invented an oscillator in 1918 – took 11 years to get the US Patent (1624537). These oscillators are ubiquitous and cheap. They are used in electronic key fobs etc. They have very stable outputs. The Colpitts oscillator has three differential equations, but only one point of non-linearity (an exponential term). The voltage output looks very complex and a tiny perturbation makes a huge difference (voltage as a function of time). Importantly the weather and your brain are not Colpitts Oscillators. Professor Abarbanel suggested that hydrogen is to iron as the Colpitts Oscillator is to our brain, or the weather.

Complex phenomena are underpinned by, and understood via, simpler facts. The real issue is that there are not enough measurements of complex systems to determine the state of the complex system. While that statement is not true of the Colpitt’s Oscillator, the Colpitts Oscillator can still help with our understanding. In principle at least, by experimenting on the Colpitts Oscillator we should be able to determine all the parameters of its state. It is not easy, but it is possible. Perhaps solving it will help us with the more complex problems of the weather and our brains.

As concerns the weather it is important to note that we make 12 million weather measurements every 12 hours, but we would need at least ten times more than that if we were to make a true weather model. Tuning such a model is like tuning a radio. If you aren’t tuned you don’t stand a chance to gain understanding. The data is needed for the tuning and the trick is to be able to tune so we can extract useful information. Tuning the radio is tuning the system to a stable transmission state, but that is not true for a non-linear system. Changing the tuning settings in such cases can change the system. As such finding the parameter values for the Colpitts Oscillator is essentially impossible. It is an impossible noise of local minima. It appears impossible to stabilise (to find a minimum on which one can converge), but actually (and interestingly) it can be done. The issue is to stabilise one’s searches (an exercise in minimisation), but it is difficult. It is however vital if you want to understand a complex system.
By measuring the emitter to base voltage in the transistor based Colpitts Oscillator, can one infer the parameters of the circuit? Short term model predictions work, but soon lose registry with the data (after approximately 10ms). Any slight mismatch between best system estimate and reality will induce divergence of reality and the model. To have a chance of making even short term predictions one needs to know the starting state. Additionally, in order to have a chance of making predictions you need an ongoing series of measurements.

Errors are key (in both model parameter guesses – “the data” and in the equations themselves). In fact one needs to deal with probability estimates. That allows us to get a handle of how far ahead in the future one can predict. At this point Professor Abarbanel returned to considering the weather, and he suggested that “it’s all about liquids” and have known about liquids for 250 years. What we do with weather is divide the map into grids typically 180km on a side. Even with that coarseness of a grid one needs 8 million dimensions of the model. Yes, the weather/climate system is complex! If we reduce the grid size to 50km, then we have 104 million dimensions, but we could resolve the weather in Birmingham as distinct from London. Real state of the art weather models use 80 million to 5 billion variables depending on resolution. Between 11 and 13 million measurements are made every 12 hours. It is probably not enough. We are presently only measuring about 15% of the variables. We do not even know the necessary number of measurements.

Computers are key to all this. ENIAC in 1946 computed at a rate of 35 bits per second. Over the years we have used better computing to give better spatial resolution in weather prediction (smaller grids). However, we haven’t focussed on pulling in more measurements. Technology from Liquid Robotics in California allows robust ocean data collection at modest cost.

Next Professor Abarbanel moved on to considering the brain. Nervous systems are based on non-linear oscillators known as neurons. The basic oscillator equations have been known since the 1950s thanks to the work of Hodgkin and Huxley. The extracellular medium circuit is not so different from the Colpitts oscillator, - there are millions of neurons and even more connections. It is interestingly worse than the weather. That said he zebra finch brain is easier to study than the human brain and while cannot regard it as being akin to hydrogen spectroscopy, perhaps it’s lithium. Professor Abarbanel smiled to indicate a joke.

Zebra finch has only about one million neurons and perhaps 100 million connections (c.f. 10e15 in the human brain). In addition the Zebra finch is the smallest known animal with cultural behaviour (birdsong). One can study a neuron in vitro and drive it with a small current and study the circuit output. One can study each neuron for a few seconds before the neuron dies. Importantly one must get the initial state of the neuron, but then one can start to make predictions. One cannot live with just understanding universal macroscopic, one needs to understand the details.

After his lecture Professor Abarbanel agreed to answer questions from the audience.

**Q&A**

**Q.** If you are using only one neuron, why not use human neurons?
**A.** But if we do the finch we might, just might, be able to build a model that can sing.

**Q.** As concerns the weather – we get more measurements with time. Is such history useful? Is the historical record simply not long enough? How much historical data do we need?
**A.** I don’t know. We don’t need decades worth of data to predict tomorrow’s weather. We need good quality recent data. History can help us test models but we are not yet in that position.
Q. You chose to study the finch’s brain – is there a difference to human brains at the neuronal level?
A. No. Neurons are similar between species. What we learn across species is that it is all about neuron connectivity that is where the difference is.

Q. Does it matter that we can’t predict if we know what we can’t predict – that knowledge is very powerful.
A. Why does the BBC pay the Met Office for weather predictions? The goal is to predict. That’s the job to be done – fitting is easy – predicting is very hard. Engineering is the face of physics in society – but we must get to the underlying basics.

Report from Summer Schools Event, Imperial College London
3rd July 2014

Report by Mark Hardman

On 3rd July, pupils from four London schools visited Imperial College for a workshop on Chaos & Complexity, organised by the Nonlinear and Complex Physics Group.

Imperial PhD student Nicky Zachariou kicked off proceedings with a discussion of bird flocking and synchronisation in nature, drawing on pupils’ experiences. Next, PhD student Kishan Manani explored his work on the synchronisation of heart cells and the spontaneous beating of the heart, linking complexity physics to medical applications.
This being no ordinary workshop, we then developed a number of performing arts activities to explore synchronisation with the group: clapping, copying and moving around the room. Despite the heat of the day, pupils, teachers and researchers alike were soon embodying self-organisation!

After lunch, Dr. Moez Draief explored the application of complexity and network science to the social networks that pupils use every day, inviting them to see future opportunities in this field. Our theatrical interpretation of this explored the links between us and again allowed participants to feel the relevance of exploring complexity in their everyday lives.

Professor Kim Christensen then gave a plenary talk about the importance of chaos, complexity and nonlinearity both within research and the world more generally. He was inundated with questions from the pupils, despite a long and hot day; a testament to how engage the pupils were. Feedback (on video of course) from the pupils shows that they were really engaged by an area they were not fully aware of and we hope they will take back to their classmates a passion for complexity and nonlinear science.

With thanks to the Jugular science and theatre company who made such a unique workshop a huge success (facebook.com/JugularJoiningHeadandHeart).

Report from 4th Annual Student Conference on Complexity Science 2014

Report by Matt Garrod

This August saw the fourth annual Student Conference on Complexity Science being held at the University of Sussex. Over 200 PhD students and early career researchers descended on Brighton for an event likely to broaden the horizons of even its most seasoned veterans.

The first day kicked off with a series of workshops aimed at giving the attendees exposure to mathematical and computational techniques they may not have encountered within their own discipline. Topics included finite difference modelling and "The power of model validation". In addition, the workshop on Complexity, Evolution and the Origin of Life emphasised that Darwinism is increasingly becoming a way of thinking rather than just an isolated scientific theory. Other workshops focused on software management, model evaluations and hands-on practice with productivity tools such as git and the iPython notebook.

The first day was brought to a close by a talk from the first keynote speaker Professor Mark Newman. Newman gave an engaging and informative talk covering some of the basics of network theory and its applications. He put forth a strong case, that despite its status as a fledgling science compared to behemoths such as physics, the study of networks is becoming increasingly important since many aspects of modern life revolve around networks - social networks being a prime example of this.

Wednesday morning commenced with the second keynote speaker Professor Nigel Gilbert, one of the luminaries in the field of agent based modelling within the social sciences. Gilbert spoke about the issue of quality in computational modelling, this is an important topic for all scientists to be aware of, given that in many cases science can become geared towards purely obtaining the results, rather than ensuring their quality.

Following the talk from Professor Gilbert saw the first of three presentation sessions in which current researchers had the opportunity to give 20 minute presentations concerning their current research. The atmosphere was somewhat chaotic as attendees frantically struggled to maximise
their exposure; with subjects ranging from "Language and Social Dynamics" to "Swarm Robotics". Overall the quality of many of the speakers was high.

The second day ended with Professor Henrik Jeldtoft Jensen arguing that complexity science is the natural next step on from statistical mechanics. Despite the magnitude of the challenge, Jensen showed confidence in the idea that one day we may able to construct a unifying framework which can explain various aspects of complex systems ranging from biological systems to the global economy.

The program for Thursday covered two further presentation sessions and another poster session. These were followed by a career panel and science panel discussions. The career panel discussed the benefits that training as a complexity scientist can have in a variety of modern careers. While the science panel discussion included some debate over exactly what complexity science is and whether it really exists as a distinct field. The fourth and last keynote speaker, Professor Eors Szathmary spoke about some of the key ideas concerning evolution.

The social highlight of the final day was the conference dinner which was held at Brighton's iconic Grand Hotel. The night saw some excellent food accompanied by Avant-grade entertainment from 'Space Dog' followed by an opportunity to sample Brighton's night life.

The conference succeeded in bringing together a large number of applied mathematicians in order to explore the sheer variety of problems which modern researchers can tackle with the aid of a pen and paper or computer. Many thanks go out to the ISS at the University of Southampton for organising such a successful event.

4. Items of interest

**Unlocking Lovelock – exhibition at the Science Museum, London**

Report by Bill Nuttall

From 9 April 2014 the Science Museum in London is exhibiting, for one year, a special show dedicated to the life and work of James Lovelock. If I have a scientific hero it is Lovelock – a truly independent thinker with impacts ranging from the deeply philosophical to the utterly practical. I was therefore delighted to see recently the current exhibition in London. The context of the exhibition is that Professor Lovelock (or ‘Jim’ as he is known to many) has donated his vast archive and accumulated collection of scientific miscellany and inventions to the museum. The museum’s curators have started to look at what they have received and were able to use it to illustrate Lovelock’s life. I suggest the exhibition is best suited to those already reasonably familiar with Lovelock’s life and works and I should say it is not the best Science Museum attraction for kids. For members of the Nonlinear and Complex Physics Group of the IOP, however, it is close to perfect.

http://www.sciencemuseum.org.uk/lovelock
Think for a moment about your favourite piece of music or artwork. Now consider the fact that the artist who produced it almost certainly had their own favourite piece, which influenced their life just as much. The process of how artists and creators influence each other and draw influences from previous generations provides one example of a complex adaptive system in a social context.

Complex systems are typically composed of many entities known as agents. An agent could be a molecule in a chemical reaction, an animal in an ecosystem, someone in a crowd or a myriad of other possibilities. There is no single definition of a complex adaptive system, though some of their main features are neatly summed up by John Holland [1]. These include: the presence of many interacting agents, nonlinear interactions between these agents, diversity among agents, as well as “Internal models” employed by the agents. The latter can be thought of as a set of rules which an agent obeys when faced with a situation. For example, people moving in a large crowd will, on average, tend to stay a certain distance from each other.

The presence of non-linear interactions between agents in a system is often synonymous with chaotic behaviour. This can be described as “irregular behaviour in a deterministic system which persists over a long time and exhibits sensitivity on initial conditions.” [2] The point of this being: if you throw a stone of a given mass into a pond in which linear interactions occur, you’ll probably know how big the splash will be. However, in a chaotic system, a slight difference in the mass of the stone or the trajectory at which you throw it could mean the difference between a few ripples and a tsunami.

The result of all this uncertainty is that scientists often turn to computer models when studying complex systems. A good example of one of these models in the context of social influence is Robert Axlerod’s 1997 work on “The Dissemination of Culture” [3]. His model consisted of a series of agents placed at fixed sites on a two-dimensional grid, much like a chessboard. Each agent possessed a set of features which could take a series of different values. For example, if the feature was hair colour the values may correspond to blonde, brunette or black.

We can imagine the situation as a packed auditorium in which the audience have turned up with a random selection of clothes, hairstyles and other features. Each member of the audience can only talk to, or “interact” with, their immediate neighbours with a probability based on how much they have in common. The population of this world is easily swayed; the outcome of a conversation with someone will result in them changing one of their features to copy their neighbour.

The simulation was typically allowed to run until no more changes occurred to the features possessed by any of the agents. Axlerod often found that the end result would be a series of different homogeneous regions between which no interaction could occur due to a lack of any common features. In this case our audience has changed from being effectively random to something more like the stereotypical American high-school canteen, split into different cliques. This process is also comparable to the formation of different nations within the same continent over time.

To make an analogy between Axlerod’s model of social influence and the process of creative
influence we could imagine giving everyone in our audience a canvas and paint. The formation of large homogeneous regions could now correspond to whole swathes of the population all deciding to paint boats. This concept emphasizes where our comparison between the cultural influence analysed in Axlerod’s model and creative influence breaks down. In creative endeavours, it is typically undesirable to copy others’ work (though this doesn’t stop some people trying). To compensate for this, one could imagine Axlerod’s model being adapted for use in the study of creative influence by placing a limit on the number of features shared by agents.

Another aspect Axlerod considered was the effect of the range of interactions on the size of the regions formed. It was discovered that the number of homogeneous regions decreased as the range of interaction increased [3]. In modern times the range of interactions between individuals in society can be thought of as effectively limitless; this is due to the presence of the internet and other remarkable means of communication. This implies that the effect of enhanced communication and transport on humanity is to promote increased homogeneity; this forms the basis of the concept of globalization.

Despite the importance of interactions between creative individuals in determining what they produce, it is important not to ignore the “internal model” within each agent. In the case of humans this is the human brain, which is arguably more complicated and more difficult to study than the interactions between its owners.

In summary, simple models such as that devised by Axlerod can provide a surprising amount of insight into how complex adaptive social systems behave. However, unravelling the creative process once and for all is sure to require thorough dialogue between neuroscience, computer science and the more general study of complex systems. As is often the case in science, analogies between models and reality should not be stretched too far. Nevertheless, through careful comparison with real measured data, these models have the potential to become relevant to the real world.

References


This featured article was contributed by Matt Garrod of the University of Manchester, who is the 2014 winner of the NCPG Student Essay Competition.

Do you have an article you’d like to share? If so please get in touch.
6. Group Committee

Chair: Dr Tobias Galla MInstP

Tobias Galla is a Senior Lecturer in the Complex Systems and Statistical Physics Group at the University of Manchester (UK). He holds a Diplom (Physik) from the University of Muenster/Germany (1999), and a DPhil (PhD) in theoretical physics from the University of Oxford/UK (2004). He works on the statistical mechanics of complex systems, in particular stochastic dynamics of agent-based models, with applications in biology, pattern formation, economics, game theory and social dynamics. Galla has (co-) organized two three-day meetings on complexity for UK and international postgraduate students, as well as five one-day mini-symposia during the spring of 2012 on different topics in complexity science (e.g. stochastic pattern formation, noise in biochemical systems, mathematical modelling in finance), and a three-day retreat for students and researchers at the University of Manchester. He has given public engagement talks to more than 3,000 Sixth Form pupils.

Secretary: Dr Jean Boulton CPhys FInstP

Jean Boulton is a Visiting Senior Research Fellow in the Department of Social and Policy Sciences at the University of Bath and a Visiting Fellow at the Cranfield School of Management. She is also a Fellow of the Institute of Physics. Her research interests and teaching focus around complexity theory and its application to the social sciences, policy and strategy. Jean is currently in the process of completing a book titled 'Embracing Complexity' with her colleagues from Cranfield, for the Oxford University Press and maintains a website and blog on the topic at www.embracingcomplexity.com.

Treasurer: Dr Alain Nogaret CPhys MInstP

Dr Alain Nogaret is a senior lecturer at the University of Bath, where he develops artificial neurons and neural network hardware. His current research focuses on the dynamic properties of neurons that compete within networks, stochastic dynamics, the homotopic programming of neural hardware and the development of artificial central pattern generators as new medical therapies to artificially control biological rhythms e.g. respiratory sinus arrhythmia in rats.
Ordinary Members:

**Dr Martine Barons MSc AMInstP**

Martine Barons has recently completed her PhD at the University of Warwick Centre for Complexity Science. Martine researched Complexity in Healthcare and specifically "What is the added value of using non-linear models to explore complex healthcare datasets?" Martine is now employed in the University of Warwick Department of Statistics, on a 3-year postdoc with Prof. Jim Smith is called "Coherent inference over a network of probabilistic systems for decision support with applications to food security". In this project we will find sufficient conditions for coherently drawing together the probabilistic judgments of different panels of experts distributed over a network and measures for the lack of coherence when full coherence is not possible. This will require the analysis of Bayesian networks using algebraic statistics, as well as eliciting conditional probabilities from panels of experts. The application area is food security. Martine met Tobias at the Complexity summer school in Ambleside in 2008 and, along with some of the other students from there, they were successful in setting up and running young researchers meetings at ECCS, which they have now handed on and continues under the name of the Young Researchers Network.

**Mr Mark Hardman MInstP**

Mark Hardman runs programmes at Imperial College and Canterbury Christ Church University training physics teachers, particularly those with a research background. He is writing up his thesis on how classrooms can be described as complex systems, trying to add some rigour to the truism that classrooms are complex and often chaotic. He also has a pet tortoise.

**Dr William Nuttall CPhys FInstP**

Bill Nuttall is Professor of Energy at the Open University. He has previously been a Senior Lecturer in Technology Policy at the University of Cambridge, where he was also the Director of the Management of Technology and Innovation (MoTI) Programme and Assistant Director of the Electricity Policy Research Group. Bill's research centres upon issues concerning energy technologies and public policy. A major area of activity relates to nuclear energy, the nuclear fuel cycle and possibilities for advanced nuclear energy technologies. His research includes the application of System Dynamics especially to issues of resource depletion. He has also undertaken research using techniques of spatial agent-based simulation.

**Dr Nicholas Watkins MInstP**

Nick Watkins is a complexity analyst, and is currently a senior visiting scientist at the Max Planck Institute for the Physics of Complex Systems, Dresden, Germany. He is also a visiting professor at the Open University, and a visitor to the Centre for the Analysis of Time Series (CATS) at LSE and the Centre for Fusion Space and Astrophysics at Warwick. Nick's career has spanned a PhD in condensed matter theory; postdoctoral experience in space plasma data analysis and instrument modelling at Sussex and Warwick; and a civil service post at the British Antarctic Survey (BAS). Here he led a team that developed and applied complexity science across BAS's remit, from heavy tails in the Earth's fluctuating aurora to long range dependence in temperature, and complex networks in biology. The common threads through this very diverse range of topics have been fluctuations in complex systems and time series analysis.
Dr Emma Suckling MInstP

Emma Suckling is a Research Officer within the Centre for the Analysis of Time Series (CATS) at the London School of Economics. Her research interests include developing informative forecast systems for the EQUIP project, which brings together climate modelling, statistical modelling and impacts communities to deliver risk-based prediction for decision making in the face of climate variability and change. She is a physicist by training, having pursued both her undergraduate degree and a PhD in theoretical nuclear physics at the University of Surrey, before joining CATS in 2010.

Mr Matthew Garrod

Matt Garrod is a fourth year undergraduate student at The University of Manchester studying for an MPhys in Physics with Theoretical Physics. His current research project is on the stochastic dynamics of bacteria growth. In the summer of 2014 he carried out research into the evolution of sex determination mechanisms within The University of Manchester's Computational and Evolutionary Biology Research Group. His research interests fall broadly within the domain of complex systems and nonlinear physics.

Mr Bernd Taschler

Bernd Taschler is currently a PhD student at the Centre for Complexity Science, University of Warwick. His research interests are centred around modelling of neuroimaging data, with a particular focus on magnetic resonance imaging of multiple sclerosis. For his work on MS, Bernd is collaborating with the Medical Image Analysis Center at the University Hospital Basel, Switzerland. Before moving to Warwick, Bernd obtained a Diplom in theoretical physics from the University of Technology in Graz, Austria, where he worked on strongly correlated many-body systems. He has spent a year as an exchange student at Inha University, South Korea, as a visiting member of the Nuclear Theory Group and has been a teaching assistant for several undergraduate physics courses. He also knows how to play saxophone.
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