The second ICMS complexity science winter school introduces complexity science with applications in the engineering, biological and related sciences. The school consists of two parts: the first part consists of three days of tutorial lectures, which provide an excellent base for the invited topical lectures that are cover the second part.

The presence and delivery by internationally recognized lecturers is key to the success of an advanced study school and we are very grateful for their acceptance to lecture. After the tutorial lectures there is time available in the program for discussions between participants and lecturer.

To stimulate interaction between the participants we have invited PhD students and postdoctoral researchers to present a poster, exposed at two occasions. Lunches and supper are included in the day program. On Wednesday afternoon a social event is organized.

The winter school is organized by Institute of Complex Molecular Systems (ICMS) of Eindhoven University of Technology (TU/e). Cosponsoring organizations are Netherlands Platform Complex Systems (NPCS), Eindhoven Multiscale Institute (EMI) and Dutch Institute of Systems and Control (DISC).

We wish you all a very useful and pleasant week,

The Organizing Committee:

Rutger van Santen  
(Chemical systems)

Mark Peletier  
(Mathematics)

Henk Nijmeijer and Erik Steur  
(Dynamical control systems)

Bert Meijer  
(Molecular systems)
(1 hour = 45 minute lecture + 15 min break)

**Monday, February 13**

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<tr>
<td>10.30 - 11.00</td>
<td>Coffee and welcome</td>
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<tr>
<td>11.00 - 11.15</td>
<td>Opening</td>
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<tr>
<td>11.15 - 12.00</td>
<td><strong>Tutorial lectures</strong>&lt;br&gt;R. Sepulchre <em>(Complexity and simplicity of neurophysiological dynamical behaviors)</em> part 1</td>
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<tr>
<td>12.00 - 13.00</td>
<td>R. Sepulchre <em>(Complexity and simplicity of neurophysiological dynamical behaviors)</em> part 2</td>
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<td>13.00 - 14.00</td>
<td>Lunch</td>
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<tr>
<td>14.00 - 15.00</td>
<td>R. Sepulchre <em>(Complexity and simplicity of neurophysiological dynamical behaviors)</em> part 3</td>
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<tr>
<td>15.00 - 16.00</td>
<td>Coffee break&lt;br&gt;Informal questions/discussion R. Sepulchre</td>
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<tr>
<td>16.00 - 17.00</td>
<td>B. Nienhuis <em>(Asymmetric simple exclusion processes)</em> part 1</td>
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<tr>
<td>17.00 - 18.00</td>
<td>Drinks&lt;br&gt;Poster session 1</td>
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<td>18.00 - 19.00</td>
<td>Supper</td>
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**Tuesday, February 14**

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<tr>
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<td><strong>Tutorial lectures</strong>&lt;br&gt;B. Nienhuis <em>(Asymmetric simple exclusion processes)</em> part 2</td>
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<tr>
<td>10.30 - 11.15</td>
<td>B. Nienhuis <em>(Asymmetric simple exclusion processes)</em> part 3</td>
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<tr>
<td>11.15 - 11.45</td>
<td>Coffee break</td>
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<tr>
<td>11.45 - 12.45</td>
<td>Informal questions/discussion B. Nienhuis</td>
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<tr>
<td>13.00 - 14.00</td>
<td>Lunch</td>
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<tr>
<td>14.00 - 15.00</td>
<td>T. Vicsek <em>(Complexity science and its applications in biophysics and sociology)</em> part 1</td>
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<tr>
<td>15.00 - 15.45</td>
<td>T. Vicsek <em>(Complexity science and its applications in biophysics and sociology)</em> part 2</td>
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<td>15.45 - 16.15</td>
<td>Coffee break</td>
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<tr>
<td>16.15 - 17.15</td>
<td>T. Vicsek <em>(Complexity science and its applications in biophysics and sociology)</em> part 3</td>
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<tr>
<td>17.15 - 18.15</td>
<td>Informal questions/discussion T. Vicsek</td>
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<tr>
<td>18:15 - 19.15</td>
<td>Drinks&lt;br&gt;Poster session 2</td>
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<td>19.15 - 20.15</td>
<td>Supper</td>
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### Wednesday, February 15

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<tr>
<td>09.00 - 10.00</td>
<td>Tutorial lecture</td>
<td>R. van der Hofstad (Modeling structure and function of complex networks and the brain) part 1</td>
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<tr>
<td>10.00 - 10.45</td>
<td>R. van der Hofstad (Modeling structure and function of complex networks and the brain)</td>
<td>part 2</td>
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<tr>
<td>10.45 - 11.15</td>
<td>Coffee break</td>
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<tr>
<td>11.15 - 12.00</td>
<td>R. van der Hofstad (Modeling structure and function of complex networks and the brain)</td>
<td>part 3</td>
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<tr>
<td>12.00 - 13.00</td>
<td>Informal questions/discussion</td>
<td>R. van der Hofstad</td>
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<tr>
<td>12.40 - 13.30</td>
<td>Studium Generale lecture</td>
<td>T. Vicsek (From flocks of birds to swarming robots)</td>
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<tr>
<td>13.30 - 14.30</td>
<td>Lunch</td>
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<tr>
<td>14.30 - 21.00</td>
<td>Social program and supper</td>
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<td>Topical lectures: complex materials</td>
<td>M. v. Hecke (Mechanical Metamaterials)</td>
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<td>10.30 - 11.00</td>
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<tr>
<td>11.00 - 11.45</td>
<td>B. Overvelde (Soft Robotic Matter)</td>
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<tr>
<td>11.45 - 12.30</td>
<td>S. Otto (Emergent behavior from networks of interacting and interconverting molecules. Or: can we make life in the lab?)</td>
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<tr>
<td>12.30 - 13.30</td>
<td>Lunch</td>
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<tr>
<td>13.30 - 14.30</td>
<td>Topical lectures: crowd dynamics</td>
<td>E.N.M. Cirillo (Obstacle induced particle jamming in exclusion dynamics)</td>
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<tr>
<td>14.30 - 15.30</td>
<td>C. Hemelrijk (The self-organised dynamics of shape and internal structure of flocks of starling)</td>
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<tr>
<td>15.30 - 16.00</td>
<td>Coffee break</td>
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<tr>
<td>16.00 - 17.00</td>
<td>F. Toschi (Statistical crowd dynamics)</td>
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<tr>
<td>17.00 - 18.00</td>
<td>Drinks</td>
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<tr>
<td>18.00 - 19.00</td>
<td>Supper</td>
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### Friday, February 17

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<th>Time</th>
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<tr>
<td>09.00 - 10.00</td>
<td>Topical lectures: complex dynamics</td>
<td>P. v.d. Hof (Data-driven modelling in linear dynamic networks)</td>
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<tr>
<td>10.00 - 11.00</td>
<td>B. Jayawardhana (Handling genome-scale kinetics models through structure-preserving model order reduction)</td>
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<td>11.00 - 11.30</td>
<td>Coffee break</td>
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<tr>
<td>11.30 - 12.30</td>
<td>H. Nijmeijer (Simple network, complex dynamics or complex network, simple dynamics?)</td>
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<td>12.30 - 13.30</td>
<td>E.A. Martens (Chimera states - mythological monsters from mathematics arise in the real world)</td>
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<td>13.30 - 13.45</td>
<td>Closure</td>
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<tr>
<td>13.45 - 14.45</td>
<td>Lunch</td>
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</table>
Abstract

Lecture 1: Feedback, sensitivity, and complexity
A central paradigm of control theory is that feedback shapes sensitivity. This lecture will review the basics of this theory and its relevance to analyse complex systems, when understood as large networks of interconnected systems.

Lecture 2: Sensitivity analysis of neuronal behaviors
The heritage of Hodgkin and Huxley confers a unique place to neurophysiology in the general challenge of assisting biological experimentation with mathematical modeling.

Detailed quantitative knowledge of the ion channels controlling the excitability of a specific neuron type can be incorporated in conductance based models, leading to mathematical models governed by high-dimensional nonlinear differential equations that can simulate experimental predictions with great accuracy. Ever increasing computational power and improving knowledge about the connectome of neural circuits thus suggest the possibility of reliable simulation of large scale neural simulations.

In this second lecture, we will review the modeling principles of those behaviors and illustrate that some of the simplest sensitivity analysis questions of an experimentalist are intractable or extremely fragile in this nonlinear state-space framework.

We will contrast the complexity of large-scale conductance-based models with the simplicity of neuronal behaviors that they aim at reproducing. This calls for alternative modeling principles with a narrower gap between experimental questions and model-based answers. We will argue that excitability is at the core of neuronal behaviors and that the specifics of excitability pave the way to local analysis methods.

Lecture 3: Switchlets: analysis and design of multiresolution sensitivity
Balancing positive and negative feedback provides a versatile mechanism to localize the sensitivity of a behavior in a given window. And the mixed feedback amplifier is the essence of excitable behaviors. This third lecture will illustrate how localized behaviors can be interconnected to create behaviors that can be analyzed and designed at different resolutions.

Biography
Rodolphe Sepulchre is Professor of Engineering at Cambridge University and a fellow of Sidney Sussex College. His research interests are in nonlinear dynamics, control and optimization. He is currently Editor-in-Chief of Systems and Control Letters and has been an Associate Editor for SIAM Journal of Control and Optimization, the Journal of Nonlinear Science, and Mathematics for Control, Signals, and Systems. In 2008, he was awarded the IEEE Control Systems Society Antonio Ruberti Young Researcher Prize. He is an IEEE fellow and an IEEE CSS distinguished lecturer since 2010. His current research interests are in nonlinear control and optimization, distributed control and synchronization, and the analysis of neuronal behaviors.
Abstract
There are many systems in nature and society where objects that are not allowed to overlap, move in a preferred direction along a one-dimensional trajectory. An obvious example is automobile traffic on a single lane road. Another case is the motion of molecular motors in a living cell, along a microtubule. Such processes are collectively called 'Asymmetric exclusion processes' (ASEP). 'Asymmetric' from the fact that the motion has a preferred direction, and 'exclusion' from the fact that the objects take space which is not overlapped by other particles. Further properties defining the ASEP class, is that one considers only local, Markovian processes. These are stochastic processes in which the transition probability is fully determined by the current state, and which allow only changes within a finite range, depending on the current configuration within a finite distance from the change.

Besides those properties many specifics vary. There may be one or more species of particles, time as well as space can be continuous as well as discrete. One can study dynamic time dependence or stationary probabilities. The motion may be exclusively unidirectional, or only preferentially.

In these lectures I will discuss a selection of relatively simple models that have been studied in the literature, with the aim of elucidating a number of different methods, such as the matrix product method, Bethe Ansatz. In addition I will focus on the connection of the ASEP system to other well-studied problems, such as growth problems.

Biography
Bernard Nienhuis earned his PhD in 1978 in Utrecht on the subject of Renormalisation Theory. He worked in the field of critical phenomena at the universities of Washington, Delft and Chicago, and then switched to the area of artificial intelligence at Philips and visual perception in Utrecht. He pursues his current interests in solvable many body systems at the University of Amsterdam, where he has a chair since 1989.
COMPLEXITY SCIENCE AND ITS APPLICATIONS IN BIOPHYSICS AND SOCIOLOGY / FROM FLOCKS OF BIRDS TO SWARMING ROBOTS

TAMÁS VICSEK

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Abstract

Lecture 1: Collective motion: examples and a simple model
The individual actions of moving animals or robots may add up, and create patterns of motion, so complex that they seem to have been choreographed from above. Flocks and schools have a distinctive style of behaviour - with fluidity and a seeming intelligence that far transcends the abilities of their members. Vast congregations of birds, for example, are capable of turning sharply and suddenly en masse, always avoiding collisions within the flock.
Flocking of birds has been the subject of speculations and investigations for many years. The most impressive displays of collective motion are produced by flock of birds and fish schools, but interesting patterns of collective motion can be observed in numerous other systems including swarms of bacteria, amoebae, locusts, mammals and even people.
Models of flocking are relevant for both the revealing of the underlying fundamental rules acting on the level of individual interactions and various engineering applications.

Lecture 2: Statistical mechanics of collective motion
Standard statistical mechanics is a very successful approach to the interpretation of how an ensemble of particles behaves in equilibrium, or close to equilibrium. The related theories and concepts (such as, e.g., growth of entropy in a closed system, universality, etc.) have been capable of explaining a large number of observed phenomena. However, most of the assumptions used to derive the major results or building the lucrative theories have assumed conditions that are explicitly violated in a system where the units tend to move on their own, even without being “kicked” by another particle.
The essential difference between collective motion in standard statistical physics and biology is that the “collision rule” is principally different in the two kinds of systems: in the latter ones it does not preserve the momenta (the momentum of two self-propelled particles before and after their interaction is not the same), assuming that we consider only systems made of self-propelled particles (SPP-s which tend to maintain a given absolute velocity).
Interestingly enough, in spite of the above essential differences, many far-from-equilibrium systems of SPP-s can be described in terms of quantities which have their analogues introduced to and calculated by statistical mechanics. Furthermore, simulations and continuum equations support the idea that even some of the fundamental relations among these quantities have their counterparts in equilibrium statistical mechanics.
Lecture 3: Group decision-making on the move
Social structure has the potential to impact the way in which information flows through groups and the group decisions that emerge during collective action. The structure of social ties can depend on many factors, in particular, on the context in which they manifest themselves. In fact, collective motion itself involves decisions (e.g., about which direction to take) by the group members.

More complex situations include decision-making aimed at a decision which is optimal for both the individuals as well as for the whole group. For example, in the case of advancing towards several potentially useful locations of resources, a group can split, choose to follow a better informed member or land as a whole to have a rest.

As it turns out, a hierarchical network structure is the most beneficial in many of the cases when the process of decision making depends on such factors as the ability of the individuals to provide a good guess about the best solution, or their tendency to follow the decision of the others. Thus, we shall introduce models that lead to hierarchy in a self-organized fashion and shall quantitatively interpret some of the associated relevant questions.

Lecture Studium Generale: From flocks of birds to swarming robots
When advancing together, animals or people have to make collective decisions on the move in order to both achieve the given goal of their joint journey and stay together, because the latter feature has many advantages. It turns out that a few basic ingredients of the decision-making process result in a fascinating variety of complex behavioral patterns. With examples ranging from coherently moving bacteria to flocks of birds and the spectacular flight of a group of unmanned aerial robots, prof. Tamás Vicsek explains how to find the most common rules underlying the large scale processes that take place during collective motion.

Biography
Prof. dr. Tamás Vicsek [http://hal.elte.hu/~vicsek/] is Professor of Physics at the Department of Biological Physics, Eotvos University, Budapest. Over the past 30 years, he has been involved in computational and experimental research on fractals, pattern formation, the collective motion of units in a wide selection of systems and the structure and evolution of complex networks.
MODELING STRUCTURE AND FUNCTION OF COMPLEX NETWORKS AND THE BRAIN

REMCO VAN DER HOFSTAD

Institute for Complex Molecular Systems, Department Eurandom and Department Stochastics W&I, Eindhoven University of Technology, the Netherlands

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Abstract
Since 1999, network science has clearly established itself as one of the most interdisciplinary fields in science. In this course, we discuss the structure of complex networks in general, before zooming into their recent applications to the brain.

Empirical findings have shown that many real-world networks share fascinating features. Indeed, many real-world networks are small worlds, in the sense that typical distances are much smaller than the size of the network. Further, many real-world networks are scale-free in the sense that there is a high variability in the number of connections of the elements of the networks. Therefore, such networks are highly inhomogeneous.

Spurred by these empirical findings, random graph models have been proposed for such networks. In this course, we discuss several empirical findings of real-world networks such as the Internet and the World-Wide Web, and describe some of the models proposed for them. We then focus on some of the topological features of these models, such as their small-world behavior and clustering, and compare the results to the empirical evidence.

Arguably the largest and least understood complex network is the brain viewed as a collection of interconnected neurons. We discuss some of the network representations of the brain, as well as models that have been proposed for it, both for its structure as well as for its functionality.

We expect no prior knowledge about probability or neuroscience.

Biography
Remco van der Hofstad received his PhD at the University of Utrecht in 1997, under the supervision of Frank den Hollander and Richard Gill. Since then, he worked at McMaster University in Hamilton, Canada and Delft University of Technology. He is currently full professor in probability at Eindhoven University of Technology. Further, he is jointly with Frank den Hollander responsible for the ‘Random Spatial Structures’ Program at EURANDOM. Remco received the Prix Henri Poincaré 2003 jointly with Gordon Slade, the Rollo Davidson Prize 2007 and is a laureate of the ‘Innovative Research VIDI Scheme’ 2003 and ‘Innovative Research VICI Scheme’ 2008. He is also one of the 11 co-applicants of the Gravitation program NETWORKS.
MECHANICAL METAMATERIALS

MARTIN VAN HECKE

Leiden Institute of Physics, University of Leiden, the Netherlands

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Abstract
The unusual properties of mechanical metamaterials, such as negative and extreme responses, cloaking, topological insulation and programmability, derive from careful design of their microstructure. Periodic microstructures are common as they limit the design problem to that of a single building block, and we discuss a few recent examples of such materials and their unusual properties. Then, we introduce a combinatorial design strategy, which opens up a huge but discrete design space for metamaterials with spatially heterogenous, textured functionalities. We fabricate textured metacubes by 3D printing and demonstrate that they can smoothly morph into textured structures with controlled surface topographies, such as a smiley face.

Biography
Martin v. Hecke got his PhD in theoretical physics in 1996 at the University of Leiden. Since then he has worked on a broad range of topic in soft matter, including pattern formation and chaos, granular media, foams, rheology and jamming, combining experiments, simulations and theory. The common thread in all this works is the fascination for the emergence of complex behavior in seemingly simple systems.
In 2008 he was appointed as professor in the ‘organization of disordered media’ in Leiden and after been awarded the Vici grant in 2011, he has refocused his research towards mechanical metamaterials, from patterned elastic media to origami. His main current fascination is the inverse problem: to design and make simple materials for which desired complex behavior emerges.
Abstract
The main focus of this talk is on the design of non-linear structures and devices that exhibit a nontrivial relation between input and output (i.e. loading and response). We propose analytical, computational and relatively simple experimental techniques that allow us to effectively explore the design space of systems ranging from actuated origami-inspired transformable metamaterials to soft actuators and metamaterials that harness elastic instabilities. I will also briefly touch upon future directions that focus on the role that feedback between sensing and actuation could play in these systems, and how we plan on incorporating this feedback in artificial materials.

Biography
Bas Overvelde is the third group leader hired in the Designer Matter initiative, a recently started line of research at AMOLF. Between 2004 and 2012, Overvelde studied applied physics and mechanical engineering at the Delft University of Technology, where he received both his BSc and MSc degrees in mechanical engineering cum laude. In April 2016, Overvelde finished his PhD in applied mathematics at Harvard University under the direction of professor Katia Bertoldi at the John A. Paulson School of Engineering and Applied Sciences. Overvelde’s PhD research focused on harnessing compliance and instabilities in engineered structural materials and devices to achieve function.
EMERGENT BEHAVIOR FROM NETWORKS OF INTERACTING AND INTERCONVERTING MOLECULES. OR: CAN WE MAKE LIFE IN THE LAB?

SIJBREN OTTO

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Abstract

How the immense complexity of living organisms has arisen is one of the most intriguing questions in contemporary science. We have started to explore experimentally how organization and function can emerge from complex molecular networks in aqueous solution. We focus on networks of molecules that can interconvert, to give mixtures that can change their composition in response to external or internal stimuli. Molecular recognition between molecules in such mixtures leads to their mutual stabilization, which drives the synthesis of more of the privileged structures (Figure 1). As the assembly process drives the synthesis of the very molecules that assemble, the resulting materials can be considered to be self-synthesizing. Intriguingly, in this process the assembling molecules are replicating themselves, where replication is driven by self-recognition of these molecules in the dynamic network. The selection rules that dictate which (if any) replicator will emerge from such networks are starting to become clear. We have observed that factors such as mechanical energy and the presence of cosolvents can determine which replicator wins the competition for building blocks. We have also witnessed spontaneous differentiation (a process akin to speciation as it occurs in biology) in a system made from a mixture of two building blocks. When such systems are operated under far-from-equilibrium flow conditions adaptation of the replicators to a changing environment can occur. Thus, the prospect of Darwinian evolution of purely synthetic molecules is tantalizingly close and the prospect of synthesizing life de-novo is becoming increasingly realistic.

Figure 1. Molecular recognition between molecules in a dynamic molecular network can lead to self-synthesizing materials, build up from self-replicating molecules.

References

Biography
Sijbren Otto received his MSc (1994) and PhD (1998) degrees cum laude from the University of Groningen in the Netherlands. He worked on physical organic chemistry in aqueous solutions in the group of Prof. Jan B. F. N. Engberts. In 1998 he moved to the United States for a year as a postdoctoral researcher with Prof. Steven L. Regen (Lehigh University, Bethlehem, Pennsylvania) investigating synthetic systems mediating ion transport through lipid bilayers. In 1999 he received a Marie Curie Fellowship and moved to the University of Cambridge where he worked for two years with Prof. Jeremy K. M. Sanders on dynamic combinatorial libraries. Sijbren started his independent research career in 2001 as a Royal Society University Research Fellow at the University of Cambridge in the UK and accepted an appointment as Assistant Professor at the University of Groningen in 2009 and was promoted to Associate Professor in 2011 and Full Professor in 2016.
Abstract
Biased exclusion dynamics on a two-dimensional lattice is considered. Particles enter a strip through its left boundary and eventually exit it through the right boundary. The effect of obstacles on the time needed by the particles to cross the strip is investigated mainly numerically. Non-monotonic behaviors with respect to the width of the obstacle are found.

Results can be interpreted via a Mean Field approximation based on the knowledge of the stationary density distribution.

This research has been carried out in collaboration with A. Muntean, O. Krehel, and R. van Santen.

Biography
Emilio Cirillo is an associate professor in Mathematical Physics at the Sapienza University of Rome. In 1997 he obtained his PhD-degree in Theoretical Physics at the Physics Department of the Università degli Studi di Bari. His main scientific interests include statistical mechanics, interacting particle systems, rigorous results and computer simulations.
THE SELF-ORGANISED DYNAMICS OF SHAPE AND INTERNAL STRUCTURE OF FLOCKS OF STARLINGS

CHARLOTTE HEMELRIJK

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Abstract
Coordination of birds, such as starlings, in large, travelling flocks of thousands of individuals is amazing, especially, since individual birds adjust their movement only to a few neighbors close by. To explain what processes may underlie the many characteristics of flocks, computational models are needed. Models of self-organization have proven increasingly useful. Here we use such a model (called StarDisplay)[1]. In this talk we examine what causes the dynamics of flock shape and internal structure in huge flocks of starlings in the absence of predatory attacks [2] and during a wave of agitation evoked by an attack on starling flocks [3].

Using this model, we show in three subsequent steps:

1. The local rules that suffice to generate the variation in flock shape and spatial positions of flock members

2. The processes that may underlie the emergence of variation of shape and internal structure of flocks of birds and their absence in schools of fish,

3. What is needed to generate the internal structure in flocks, during waves of agitation

References

Biography
Charlotte Hemelrijk is professor of self-organization in social systems. Within the Groningen Institute for Evolutionary Life Sciences (GELIFES), she concentrates on primates, fish and birds. Hemelrijk studied biology and gained her PhD with a thesis on the social behaviour of chimpanzees. From 1991 to 2003, she worked at the laboratory of Artificial Intelligence at the University of Zurich, where she conducted research on artificial social systems and she obtained her habilitation. In 2003 she became a Rosalind Franklin Fellow at the University of Groningen, where she was appointed Professor of Self-organization of Social Systems in 2006.
Abstract
The dynamics of single individuals and crowds is a paramount example of interacting system where emerging large scale features emerge (e.g. crowd dynamics) from the behaviour of the single individual. In this lecture we will review techniques that allowed the acquisition of an unprecedented, both in terms of quality and quantity, database of trajectories of individuals in diluted as well as in denser crowd conditions. The phenomenology of single walking pedestrians will be discussed in the context of mathematical models capable of reproducing the most prominent statistical features. Our database allowed us to quantify, in addition to average quantities, the statistical properties of fluctuation in the velocity and position of pedestrians. We will review and discuss the case of single pedestrians, the case of two pedestrians "collision" in large corridors and their possible implications to the dynamics of very dense crowds.

Biography
Professor Federico Toschi holds the chair of Computational Physics of Multi-scale Transport Phenomena in the department of Physics and in the Department of Mathematics and Computer Science at Eindhoven University of Technology. His research interests include fluid dynamics turbulence, statistical physics, micro and nano-fluids, numerical methods for fluid dynamics, high-performance computing. He has been awarded large scale computational grants (DEISA Extreme Computing Initiative, PRACE) to study the dynamics of heavy particles in turbulence and hemodynamics.
Abstract
In many areas of science and technology, increased complexity and interconnections of systems is a strong motivation for developing control and optimization methods for dynamic networks. While in the control field attention is paid to distributed and decentralized control, as e.g. in multi agent systems, data-driven modelling is still dominantly restricted to consider simple open-loop and closed-loop structures. In this seminar we consider several questions that appear when addressing the problem of data-driven modelling in structured linear dynamic networks, and we will set up a framework for addressing those questions. They include identification of a particular module within the network and questions on the choice of signals to be measured for achieving consistency of a particular module estimate. The network situation also requires a new approach to the concept of identifiability.

Biography
Paul M. J. Van den Hof received the MSc and PhD degrees from the Department of Electrical Engineering, Eindhoven University of Technology, Eindhoven, The Netherlands, in 1982 and 1989, respectively. In 1986 he moved to Delft University of Technology, where he was appointed as Full Professor in 1999. Since 2003, he has been founding co-director of the Delft Center for Systems and Control (DCSC), with appointments in the faculty of Mechanical, Maritime, and Materials Engineering, and the faculty of Applied Sciences. As of 2011, he holds a Full Professor position with the Electrical Engineering Department, Eindhoven University of Technology. From 2005-2014, he has also been the Scientific Director of the National Research and Graduate School ‘Dutch Institute of Systems and Control’ (DISC), and National Representative of the Dutch NMO in IFAC. His research interests include issues of system identification, identification for control, and model-based control and optimization, with applications in industrial process control systems, including petroleum reservoir engineering systems and high-tech systems. He is an IFAC Fellow and Fellow of IEEE, and is holder of an ERC Advanced Research Grant in data-driven modelling of dynamic networks.
Abstract
Biochemical networks are generally modelled by ordinary differential equations to simulate their behaviour and to get insight into their functioning. Such models tend to become very complex due to the large number of molecular species involved and their nonlinear kinetics. With recent progresses in genome-scale kinetic models, novel mathematical tools that can handle the model complexity are needed. Reduction of model size and complexity should help to identify which molecular interactions are essential for the characteristic dynamics of the system and to provide meaningful biological insights. In this lecture, we will review some recent results on model reduction methods for simplifying these genome-scale kinetic models.

Biography
Bayu Jayawardhana received a bachelor degree in Electrical and Electronics Engineering from the Institut Teknologi Bandung, Indonesia in 2000, a M.Eng. in Electrical and Electronics Engineering from the Nanyang Technological University, Singapore in 2003 and a PhD in Electrical and Electronics Engineering from Imperial College London, United Kingdom in 2006. He was with Dept. of Mathematical Sciences, Bath University (Bath, United Kingdom) and with Manchester Interdisciplinary Biocentre, University of Manchester (Manchester, United Kingdom). Currently he is an associate professor in Mechatronics and Control of Nonlinear Systems at University of Groningen.
Abstract
This talk focuses on network synchronization in mechanical (electrical) systems. Typically in this setting a network of multiple identical dynamic systems is considered and the question is: what is the dynamic behavior of the overall system, i.e. the dynamics in the network. Two cases will be treated in greater detail, namely the individual nodes are simple (linear) dynamic systems and the network is fairly complex, or, alternatively, the network is simple, but the node dynamics is nonlinear, chaotic or ‘complex’.

The results will be illustrated by means of real world examples ranging from cooperative vehicles to synchronized Huygens’ clocks.

Biography
Henk Nijmeijer (1955) obtained his MSc-degree and PhD-degree in Mathematics from the University of Groningen, Groningen, the Netherlands, in 1979 and 1983, respectively. From 1983 until 2000 he was affiliated with the Department of Applied Mathematics of the University of Twente. Since, 1997 he was also part-time affiliated with the Department of Mechanical Engineering of the Eindhoven University of Technology. Since 2000, he is full-time working in Eindhoven, and chairs the Dynamics and Control section. Furthermore he is scientific director of the Graduate School DISC (Dutch Institute of Systems and Control). He has published a large number of journal and conference papers, and several books, including the ‘classical’ Nonlinear Dynamical Control Systems. His main research interests are synchronization and control theory.
Abstract
The synchronization of coupled oscillators is a striking manifestation of self-organization that nature employs to orchestrate essential processes of life, such as the beating of the heart. Self-emergent synchronization of oscillating units has been observed in a spectacular variety of systems in nature and technology, including flashing fireflies, pendulum clocks, arrays of Josephson junctions, pedestrians on a bridge locking their gait, wireless networks, circadian clocks in the brain, cardiac pacemaker cells, metabolic synchrony in yeast cell suspensions, and the life cycles of phytoplankton. Today, synchronization is considered a cornerstone in the cooperative behavior of active matter, and many studies in this field have become beacons of inspiration for investigators in complex systems.

It was long thought that -- for a network of identical oscillators -- synchrony or disorder were mutually exclusive steady states. But more than a decade ago, theoretical studies revealed the intriguing possibility of dynamical states, in which the symmetry of the oscillator population is broken into a synchronous and an asynchronous part. This state of coexistence, with seemingly incongruous parts, was later named 'chimera state', alluding to the monster in Greek mythology. In the following years, numerous analytical studies involving various sources of random perturbations established chimera states as a robust theoretical concept and suggested that these states exist in complex systems in nature. Yet, at the time, a striking lack of empirical evidence raised a critical question: Are chimera states indeed characteristic to physical and natural systems? By today, experiments have demonstrated the occurrence of chimera states in a number of lab settings; and mechanical experiments that I and my collaborators conducted, suggested that chimera states may be feasible in technological systems. However, the question as of which role chimera states might play in real-world complex networks still remains an open one.

In this topical lecture, I will first give a brief introduction to synchronization theory; then I will survey some of the theory of chimera states, their experimental verification and possible applications in biology and technology.

Biography
Erik A. Martens was appointed in 2013 as an assistant professor at the University of Copenhagen, where he is affiliated with the Depts. of Biomedical Science and Mathematical Sciences, and the Dynamical Systems Interdisciplinary Network. From 2009-2012, he was postdoctoral researcher at the Max Planck Institute for Dynamics and Self-Organization in Göttingen, Germany. In 2009 he obtained his PhD-degree from Cornell University, USA. His main research interest lies in the study of complex nonlinear (dynamical) systems. Currently his research is focused on dynamics in and on vascular networks, synchronization in physiological systems, and the theory of chimera states.