Banff International Research Station
for Mathematical Innovation and Discovery

Stochastic Network Models of Neocortex (a Festschrift for Jack Cowan)
Arriving Sunday, July 13 and departing Friday July 18, 2014.

MEALS

*Breakfast (Buffet) is available 7:00–9:30 am, in the Sally Borden Building, Monday–Friday.
*Lunch (Buffet) is available 11:30 am–1:30 pm, in the Sally Borden Building, Monday–Friday.
*Dinner (Buffet) is available 5:30–7:30 pm, in the Sally Borden Building, Sunday–Thursday.
Coffee Breaks: As per daily schedule, in the foyer of the TransCanada Pipeline Pavilion (TCPL)
***Please remember to scan your meal card at the host/hostess station in the dining room for each meal.**

MEETING ROOMS

All lectures will be held in the lecture theater in the TransCanada Pipelines Pavilion (TCPL). An LCD projector, a laptop, a document camera, and blackboards are available for presentations.

SCHEDULE

Sunday	
13:00–15:00	2014 FIFA World Cup final. For football enthusiasts, the game will be shown in the BIRS MacLab Bistro not far from Corbet Hall. Venues in town include Elk and Orsman Pub, The Pump and Tap Tavern, Brew Pub in Clock Tower Mall, and The Paddock.
16:00	Check-in begins (Front Desk - Professional Development Centre - open 24 hours)
17:30–19:30	Buffet Dinner, Sally Borden Building
20:00	Informal gathering in 2nd floor lounge, Corbett Hall (Beverages and a small assortment of snacks are available on a cash honor system.)

Monday

7:00–8:45	Breakfast
8:45–9:00	Introduction and Welcome by BIRS Station Manager, TCPL.
	Lecture Session: **Physiology**
9:00	Michael Arbib (University of Southern California, Los Angeles, USA). *Jack Cowan, the Early Years: MIT, Imperial College and the move to Chicago.*
9:45	Marcelo Bertalmío (Universitat Pompeu Fabra, Barcelona, Spain). *From image processing to computational neuroscience: a neural model based on histogram equalization.*
10:30	Coffee Break, TCPL
11:00	Leon Glass (McGill University, Montréal, Canada). *Challenges for computational vision: From random dots to the wagon wheel illusion.*
11:45	Jack Feldman (University of California, Los Angeles, USA). *Breathing: Not as easy as you think.*
12:30–13:30	Lunch
13:30–14:30	Guided Tour of The Banff Centre; meet in the 2nd floor lounge, Corbett Hall
14:30	Group Photo; meet in foyer of TCPL (photograph will be taken outdoors so a jacket might be required).
14:45-15:30	Toru Ohira (Nagoya University, Japan). *Group Chase and Escapes: a pattern forming stochastic process involving many bodies.*
15:30–17:30	Poster Session. Coffee available in TCPL until 15:30.
17:30–19:30	Dinner

Tuesday

7:00–9:00	Breakfast
	Lecture Session: **Pattern Formation**
9:00	Bard Ermentrout (University of Pittsburgh, USA) *Pattern formation in neural networks – looking back over the last 35 years.*
9:45	Fred Wolf (Max-Planck-Institut für Dynamik und Selbstorganisation, Göttingen, Germany). *Putting the twist into the shift – symmetries in the architecture of the visual cortex.*
10:30	Coffee Break, TCPL
11:00	Hugh Wilson (York University, Toronto, Canada). *Stereopsis, Rivalry, and Binocular Contrast Summation: A Model Based on the Wilson-Cowan Equations*
11:45	Marty Golubitsky (Mathematical Biosciences Institute and The Ohio State University, Columbus, USA). *Symmetry and Synchrony.*
12:30–13:30	Lunch
13:30–	Free afternoon. Coffee available in TCPL until 3:30 pm. Local self-organized group hike(s), details TBD.
17:30–19:30	Dinner

Wednesday

7:00–9:00	Breakfast
	Lecture Session: **Neural Field Equations**
9:00	Stefan Rotter (University of Freiburg, Germany). *Spike Train Correlations Induced by Anatomical Microstructure.*
9:45	Wilhelm Stannat (Technical University of Berlin, Germany). *Stochastic stability of wave fronts in neural field equations..*
10:30	Coffee Break, TCPL
11:00	Oliver Faugeras (INRIA Sophia Antipolis-Méditerranée research centre, France). *Asymptotic sparse descriptions of large networks of spiking and firing rate neurons.*
11:45	Carson Chow (NIDDK/National Institutes of Health, USA). *Beyond mean field theory for spiking neural networks.*
12:30–13:30	Lunch
13:30	Bill Troy (University of Pittsburgh, USA). *Mathematical Predictions of Large Scale Neuronal Phenomena in the Brain: from Slices to Animal Brain to Humans.*
14:15	Coffee Break, TCPL
15:00	Steven Schiff (Pennsylvania State University, State College, USA). *Unification of Neuronal Spikes, Seizures, and Spreading Depression.*
15:45	Priscilla (Cindy) Greenwood (University of British Columbia, Vancouver, Canada). *Synchronization in a stochastic Wilson-Cowan oscillator network.*
16:30	Klaus Obermayer (Technical University of Berlin, Germany). *Spike rate dynamics of coupled adaptive model neurons.*
17:30–19:30	Dinner
19:30–	Jack D. Cowan (University of Chicago, USA). *After dinner remarks.* Venue: TCPL.

Thursday

7:00–9:00	Breakfast
	Lecture Session: **Criticality**
9:00	Stuart Kauffman (University of Vermont). *Criticality: Why?*
9:45	Viola Prieseman (Max-Planck-Institut für Dynamik und Selbstorganisation, Göttingen, Germany). *Self-organized criticality and spiking activity in vivo.*
10:30	Coffee Break, TCPL.
11:00	Wim van Drongelen (University of Chicago, USA). *Validation of Network Models.*
11:45-13:30	Lunch
	Lecture Session: **Signal and Noise**
13:30	Alex Dimitrov (Washington State University, Vancouver, USA). *Emergence of perceptual invariances in auditory processes*
14:15	Kresimir Josić (University of Houston, USA). *Encoding Certainty in Bump Attractors*
15:00	Coffee Break, TCPL.
15:30	Peter Thomas (Case Western Reserve University, Cleveland, USA). *On the Asymptotic Phase of Stochastic Oscillators.*
16:15	Free time / open discussion.
17:30–19:30	Dinner

Friday

7:00–9:00	Breakfast
9:00	Unscheduled time: informal discussion, working groups, enjoy the surroundings. Coffee available 10:00-11:00.
11:30–13:30	Lunch
Checkout by 12 noon.	

** 5-day workshop participants are welcome to use BIRS facilities (BIRS Coffee Lounge, TCPL and Reading Room) until 3 pm on Friday, although participants are still required to checkout of the guest rooms by 12 noon. **

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Stochastic Network Models of Neocortex (a Festschrift for Jack Cowan)
Arriving Sunday, July 13 and departing Friday July 18, 2014.

ABSTRACTS
(in alphabetic order by speaker surname)

Speaker: **Arbib, Michael** (University of Southern California, Los Angeles, USA)
Title: *Jack Cowan, the Early Years: MIT, Imperial College and the move to Chicago.*

Speaker: **Bertalmío, Marcelo** (Universitat Pompeu Fabra, Barcelona, Spain)
Title: *From image processing to computational neuroscience: a neural model based on histogram equalization.*
Abstract: There are many ways in which the human visual system works to reduce the inherent redundancy of the visual information in natural scenes, coding it in an efficient way. The non-linear response curves of photoreceptors and the spatial organization of the receptive fields of visual neurons both work towards this goal of efficient coding. A related, very important aspect is that of the existence of post-retinal mechanisms for contrast enhancement that compensate for the blurring produced in early stages of the visual process. And alongside mechanisms for coding and wiring efficiency, there is neural activity in the human visual cortex that correlates with the perceptual phenomenon of lightness induction. In this talk I will present a neural model, derived from an image processing technique for histogram equalization, that has the form of the Wilson-Cowan equations and that is able to deal with all the aspects just mentioned: this new model is able to predict lightness induction phenomena, performs local contrast enhancement and improves the efficiency of the representation by flattening both the histogram and the power spectrum of the image signal.

Speaker: **Chow, Carson** (NIDDK/National Institutes of Health, USA)
Title: *Beyond mean field theory for spiking neural networks.*
Abstract: Mean field theories have been a stalwart for studying the dynamics of networks of coupled neurons. They are convenient because they are relatively simple and possible to analyze. However, classical mean field theory neglects the effects of fluctuations and correlations due to single neuron effects. Here, I will cover some approaches for going beyond mean field theory and incorporating correlation effects. In particular, I will discuss how to include finite size effects and derive generalized Wilson-Cowan equations that include correlation information.

Speaker: **Cowan, Jack** (University of Chicago, USA)
Title: *After dinner remarks.*

Speaker: **Dimitrov, Alexander** (Washington State University, Vancouver, USA)
Title: *Emergence of perceptual invariances in auditory processes.*
Joint work with Stephen David and Jean Lienard.

Abstract: The sense of hearing is an elaborate perceptual process. Sounds reaching our ears vary in multiple features: pitch, intensity, rate. Yet when we parse speech, our comprehension is little affected by the vast variety of ways in which a single phrase can be uttered. This amazing ability to extract relevant information from wildly varying sensory signals is also ubiquitous in other sensory modalities, and is by no means restricted only to human speech.

Even though the effect itself is well characterized, we do not understand the approaches used by different neural systems to achieve such performance. In this project, I propose to test the hypothesis that broadly invariant signal processing is achieved through various combinations of locally invariant elements. I have studied locally invariant sensory processing in several biological systems and noted its widespread presence as well, and its similarity to the global processes outlined above, save for scale. The main questions I would like to address here are: 1. What are the characteristics of locally-invariant units in auditory pathways? 2. How are biological locally-invariant units combined to form globally invariant processors? 3. What are the appropriate mathematical structures with which to address and model these sensory processes?

Speaker: **van Drongelen, Wim** (Deptartments of Pediatrics, Neurology, Committee on Computational Neuroscience, Committee on Computational Neurobiology, Computation Institute, The University of Chicago, USA)
Title: *Validation of Network Models.*
Abstract: Recording techniques to examine meso- and macroscale neural activity with both high temporal and spatial resolution are not (yet) available. Since models of neural circuitry can address this resolution problem, they fulfill an important role in the exploration of neural network function. Although models create valuable insight, one important step in the modeling effort, the verification (or falsification) of model predictions is sometimes absent, often qualitative, and involves some level of hand waving.

Network function is determined by both the properties of the network nodes and their connectivity. Unfortunately, the current experimental tools for manipulation of interneuronal connectivity are fairly coarse. One example I will present is the pharmacological manipulation of all or large numbers of synapses of one or more types across the network under evaluation. Another similarly coarse approach I will discuss is the evaluation of signal components in multi-unit activity and/or similar analyses of macroelectrode recordings. A more ideal approach and starting point for the study of effects of network connectivity is to precisely control properties of a tractable set of individual connections, while the effects of such manipulation on the network activity is measured. Such a system could be envisioned by using a computer system, placed in line with a neuronal network, which is capable of simultaneously recording and perturbing individual neuronal interactions. Such a configuration would constitute the network analog of the dynamic clamp setup for single neuron studies. During the last part of the talk, I will present pitfalls and preliminary data associated with the development of such a device.

Speaker: **Ermentrout, Bard** (University of Pittsburgh, USA)
Title: *Pattern formation in neural networks – looking back over the last 35 years.*
Abstract: I will describe some recent applications of the pattern-forming capabilities of the Wilson-Cowan equations and how they show an interesting interchange of spatial and temporal resonances. In the first part of the talk, I will present a model that explores the effects of uniform flickering light and show that there is a strong correspondence between the qualitatively different spatial patterns seen at different temporal frequencies and that these explain human data for flicker-induced hallucinations. In the second part of the talk I will describe how regular spatial patterns such as stripes can induce oscillations. I will show that this can model various types of pattern-sensitive epilepsy, a new visual effect, and why some artwork causes discomfort.

Speaker: **Faugeras, Olivier** (INRIA Sophia Antipolis-Méditerranée research centre, France)
Title: *Asymptotic sparse descriptions of large networks of spiking and firing rate neurons.*
Abstract: I expose a general theory, based on large deviations principles, to describe the thermodynamic limit of large populations of stochastic rate or spiking neurons. The theory produces useful descriptions that are both sparse and complex. They are sparse because they summarize the activity of large ensembles of neurons with just a handful of stochastic equations. They are complex because these equations incorporate memory effects (they are non-Markov), and system-wide correlations. They are useful because they offer a precise way of quantifying finite size effects. I will attempt to give an intuitive flavor of the underlying maths and speculate about the potentialities of the theory for accounting for emerging behaviors.

Speaker: **Feldman, Jack** (University of California, Los Angeles, USA)
Title: *Breathing: Not as easy as you think.*
Joint work with Kaiwen Kam and Victor A. Janczewski.

Abstract: How we generate respiratory rhythm seems like a problem we should have solved by now. Why not yet? We think an important component of this failure is that we have been looking in the wrong places. We will present data that the basic rhythm of breathing does not require: pacemaker neurons [1]; postsynaptic inhibition [2]; large amplitude bursting [3]. What mechanisms are left? An essential one that has been ignored largely because it has been experimentally refractory is the neural microcircuit, and we now are discovering some basic properties that are indicative of a critical role in rhythm generation [4]. We will propose a thesis for rhythmogenesis that reflects what we now know about the kernel for breathing.

[1] Feldman JL, Del Negro CA Gray PA (2013) Annu Rev Physiol 75, 423. [2] Kam K, Worrell JW, Ventalon C, Emiliani V. Feldman JL (2013) J. Neurosci. 33: 3332. [3] Janczewski WA, Tashima A, Hsu P, Cui Y, Feldman JL (2013) J. Neurosci. 33: 5454. [4] Kam K, Worrell JW, Feldman JL (2013) J. Neurosci. 33: 9235.

Speaker: **Glass, Leon** (McGill University, Montréal, Canada)
Title: *Challenges for computational vision: From random dots to the wagon wheel illusion.*
Abstract: Even understanding the way we perceive very simple images presents a major challenge for both neurophysiologists and computer scientists. In this talk I will discuss two visual effects. In one random dots are superimposed on themselves following a linear transformation. In the second, a rotating disk with radial spokes is viewed under stroboscopic illumination, where the frequency and duration of the stroboscopic flash are varied. Though these phenomena are very different, in both correlation plays a major role in defining the structure of the image. In this talk, I will give demonstrations of these phenomena and discuss related experimental and theoretical work by ourselves and others. In particular, I focus on theory that uses the theory of forced nonlinear oscillations to predict the percept of rotating disks during stroboscopic illumination over a wide range of disk rotation speeds and strobe frequencies. Finally, I suggest that the anatomical structure of the human visual system plays a major role in enabling the amazingly rapid and accurate computation of spatial and time dependent correlation functions carried out by the visual system.

Poster presentation: *Is it possible to predict the risk of sudden cardiac death?*

Speaker: **Golubitsky, Martin** (Mathematical Biosciences Institute and The Ohio State University, Columbus, USA)
Title: *Symmetry and Synchrony.*
Abstract: Previous work on animal gaits and recent work on a generalized model for binocular rivalry proposed by Hugh Wilson both show how rigid phase-shift synchrony in periodic solutions of coupled systems of differential equations can help understand high level collective behavior in the nervous system. For gaits the symmetries predict an unexpected gait and for binocular rivalry the symmetries predict unexpected percepts. The rivalry results are joint with Casey Diekman.

Speaker: **Greenwood, Priscilla** (University of British Columbia, Vancouver, Canada)
Title: *Synchronization in a stochastic Wilson-Cowan oscillator network*
Abstract: We model subsets of interacting excitatory and inhibitory neurons sharing common synaptic efficacies and time constants by Wilson-Cowan type equations. Several E-I pairs are coupled in a Kuramoto scheme. We investigate the resulting process of phase synchronization of sustained oscillations and its joint behavior with the accompanying stochastic amplitude process, using stochastic analysis as well as simulation. This is joint work with Lawrence Ward (Psych, UBC) and Mark McDonnell (Comm Eng, U Southern Australia).

Speaker: **Josić, Kresimir** (University of Houston, USA)
Title: *Encoding Certainty in Bump Attractors.*
Abstract: Persistent activity in neuronal populations has been shown to represent the spatial position

of remembered stimuli. Networks that support bump attractors are often used to model such persistent activity. Such models usually exhibit translational symmetry: Activity bumps are neutrally stable, and perturbations in position do not decay away. We extend previous work on bump attractors by constructing model networks capable of encoding the certainty or salience of a stimulus stored in memory. Such networks support bumps that are not only neutrally stable to perturbations in position, but also perturbations in amplitude. Possible bump solutions then lie on a two-dimensional attractor, determined by a continuum of positions and amplitudes. Such an attractor requires precisely balancing the strength of recurrent synaptic connections. The amplitude of activity bumps represents certainty, and is determined by the initial input to the system. Moreover, bumps with larger amplitudes are more robust to noise, and over time provide a more faithful representation of the stored stimulus. In networks with separate excitatory and inhibitory populations, generating bumps with a continuum of possible amplitudes, requires tuning the strength of inhibition to precisely cancel background excitation.

Speaker: **Kauffmann, Stuart** (University of Vermont)
Title: *Criticality: Why?*

Speaker: **Obermayer, Klaus** (Technical University of Berlin, Germany)
Title: *Spike rate dynamics of coupled adaptive model neurons.*
Joint work with J. Ladenbauer, and M. Augustin.

How the properties of single neurons and their coupling give rise to different types of functionally relevant collective dynamics can be effectively studied using population activity models derived from recurrently coupled spiking model neurons and mathematical analysis techniques (see, for example, [1-3]). Here we first derive a low-dimensional model for instantaneous population spike rates from a network of adaptive spiking model neurons and then use this reduction method to examine how changes in neuronal excitability can (de)stabilize different network states.

Specifically, we consider adaptive integrate-and-fire neurons [4], that can well reproduce the activity of cortical neurons, and *in-vivo* like fluctuating inputs. This neuron model includes a description of slowly decaying potassium currents (so-called adaptation currents), which have been shown to strongly affect neuronal spiking activity [5,6]. We extend different reduction techniques based on the Fokker-Planck equation [2,7] to take into account adaptation currents and we evaluate the reduced population activity models in terms of spike rate reproduction accuracy for a range of biologically plausible input statistics, computational demand and implementation complexity. This approach allows for the application of powerful methods to analyze the stability of network states, where, for example, stability bounds can be calculated for general coupling topologies [8,3]. Additionally, a direct link between macroscopic quantities (network activity) and microscopic properties (neuron biophysics) is retained.

Using this framework we demonstrate how changes in neuronal excitability via adaptation currents lead to the (de)stabilization of asynchronous states as well as fast and slow oscillatory activity generated by different mechanisms. In this way we identify network regimes where switching between different dynamical states can be mediated by (top-down) neuromodulatory signals that target adaptation currents [9].

[1] X.-J. Wang, Physiol. Rev. 90 (2010). [2] E. Schaffer, S. Ostojic, L. Abbott, PLOS Comput. Biol. 9 (2013). [3] S. Ostojic, Nat. Neurosci. 17 (2014). [4] R. Brette and W. Gerstner, J. Neurophysiol. 94 (2005). [5] J. Ladenbauer, M. Augustin, K. Obermayer, J. Neurophysiol. 111 (2014). [6] M. Augustin, J. Ladenbauer, K. Obermayer, Front. Comput. Neurosci. 7.(2013) [7] S. Ostojic and N. Brunel, PLOS Comput. Biol. 7 (2011). [8] J. Ladenbauer, J. Lehnert, H. Rankoohi et al., Phys. Rev. E 88 (2013). [9] D.A. McCormick, Progr. Neurobiol. 39 (1992).

Speaker: **Ohira, Toru** (Professor, The Graduate School of Mathematics, Nagoya University, Japan)
Title: *Group Chase and Escapes: a pattern forming stochastic process involving many bodies.*
Abstract: Stochastic processes involving many bodies is what I learned from Prof. Jack Cowan as a graduate student. Here, though slightly off from neural nets, I would like to present my recent work on “Group Chase and Escape”, which is an extension connecting the traditional mathematical problem with

current interests on collective motions of animals, insects, cars, etc. I will present our basic model and its rather complex behaviors. Each chaser approaches its nearest escapee while each escapee steps away from its nearest chaser. Although there are no communications within each group, aggregate formations are observed. How these behaviors appear as a function of parameters, such as densities will be discussed. Also, we consider different expansion of this basic model. Particularly, we introduced a fluctuation. Players now make errors in taking their step directions with some probability. It turns out that some level of fluctuations works better for more effective catching. We will also discuss directions of this framework to applications

Speaker: **Priesemann, Viola** (Max-Planck-Institut für Dynamik und Selbstorganisation, Göttingen, Germany)
Title: *Avalanches in spiking activity in vivo.*
Abstract: Power-law distributions for "neural avalanches" have been observed for fMRI, MEG, EEG, and LFP activity. The principles that give rise to these power laws are still debated. Marc Benayoun, Jack Cowan and colleagues showed that such power-laws can arise from a balance of excitation and inhibition in neural networks [1]; the power-laws may alternatively reflect a critical phase transition [2], or even self-organized criticality (SOC) [3]. However, despite extensive experimental work, we surprisingly still lack evidence that also avalanches from spike activity in vivo show power law distributions. Therefore we analyzed highly parallel spike recordings from rats, cats and monkeys. In contrast to our expectations, these spike avalanche distributions did not show power laws. When comparing our in vivo spike avalanches to the Benayoun model avalanches [1], they resembled those from slightly dis-balanced networks. When comparing them to those of an established SOC model, the differences between in vivo and model avalanches could be overcome by increasing the drive to the model (i.e. eliminating the separation of time scales), and by making the model slightly sub-critical.

Potential advantages of such a driven, slightly sub-critical regime compared to SOC may be faster information processing, and keeping a safety margin from super-criticality, which has been linked to epilepsy.

[1] Benayoun, Cowan, van Drongelen, Wallace, 2010. [2] Buice & Cowan, 2009. [3] Beggs & Plenz, 2003.

Poster presentation: *Self-organized criticality as a basis for cognitive processing in vivo?*

Speaker: **Rotter, Stefan** (Laboratory for Computational Neuroscience Bernstein Center Freiburg & Faculty of Biology, University of Freiburg, Germany)
Title: *Spike Train Correlations Induced by Anatomical Microstructure.*
Abstract: Correlations in neuronal spike trains reflect the structure of the underlying network. Pairwise correlations are caused, for instance, by direct synaptic interaction and by shared input. The contributions of more indirect, multi-synaptic pathways, however, are also very important and can be described by accounting for the connectivity motifs that arise in recurrent networks of arbitrary topology. Higher-order correlations can be dealt with in an analogous way, and partial results will be presented on how one can manage the associated combinatorial problems. In recent work we were also able to demonstrate that the inverse problem of inferring (directed) connectivity from (undirected) pairwise correlations can be approximately solved by a method based on L1-optimization, provided that the networks are sparsely coupled but the level of sparsity is not too low. Applications of such methods to neuronal populations that are observed through mass signals (e.g. ECoG or MREG) are now pursued, using improved versions of the algorithm that exploit its specific algebraic structure.

[1] Pernice V, Staude B, Cardanobile S, Rotter S. How Structure Determines Correlations in Neuronal Networks. PLoS Computational Biology 7(5): e1002059, 2011. [2] Pernice V, Staude B, Cardanobile S, Rotter S. Recurrent interactions in spiking networks with arbitrary topology. Physical Review E 85: 031916, 2012. [3] Pernice V, Rotter S. Reconstruction of sparse connectivity in neural networks from spike train covariances. Journal of Statistical Mechanics P03008, 2013.

Speaker: **Schiff, Steve** (Pennsylvania State University, State College, USA)
Title: *Unification of Neuronal Spikes, Seizures, and Spreading Depression.*

Abstract: The pathological phenomena of seizures and spreading depression have long been considered separate physiological events in the brain. By incorporating conservation of particles and charge, and accounting for the energy required to restore ionic gradients, we extend the classic Hodgkin-Huxley formalism to uncover a unification of neuronal membrane dynamics. By examining the dynamics as a function of potassium and oxygen, we now account for a wide range of neuronal activities, from spikes to seizures, spreading depression (whether high potassium or hypoxia induced), mixed seizure and spreading depression states, and the terminal anoxic "wave of death". Such a unified framework demonstrates that all of these dynamics lie along a continuum of the repertoire of the neuron membrane. Our results demonstrate that unified frameworks for neuronal dynamics are feasible, can be achieved using existing biological structures and universal physical conservation principles, and may be of substantial importance in enabling our understanding of brain activity and in the control of pathological states.

Speaker: **Stannat, Wilhelm** (Technical University of Berlin, Germany)
Title: *Stochastic stability of wave fronts in neural field equations.*
Abstract: A complete and rigorous mathematical framework for the analysis of stochastic neural field equations under the influence of spatially extended noise is introduced. A geometric approach is introduced that allows to decompose the stochastic evolution into a randomly moving wave front and fluctuations. A multiscale analysis w.r.t. this decomposition then allows one to obtain rigorous stability results. A random ordinary differential equation describing the velocity of the moving wave front is derived. The fluctuations around the wave front turn out to be non-Gaussian, even if the driving noise term is a Gaussian process.

The presented geometric approach is in principle applicable to describe the statistics of any macroscopic profile driven by spatially extended noise, like, e.g., wave fronts and pulses in stochastic reaction diffusion systems.

The talk is partially based on joint work with Jennifer Krueger.

References: [1] J. Krueger, W. Stannat, Front Propagation in Stochastic Neural Fields: A rigorous mathematical framework, arXiv:1406.2675, accepted for publication in SIAM J. Appl. Dyn. Syst. [2] W. Stannat, Stability of travelling waves in stochastic bistable reaction-diffusion equations, arXiv:1404.3853.

Speaker: **Thomas, Peter** (Case Western Reserve University, Cleveland, USA)
Title: *Asymptotic Phase for Stochastic Oscillators.*
Abstract: The synchronization, entrainment, and information processing properties of spontaneously firing nerve cells may be understood in terms of the infinitesimal phase response curves (iPRC) of neural oscillator models. The iPRC quantifies the shift in the timing of an oscillation in response to a small, brief input. For deterministic dynamical models the iPRC is defined in terms of the oscillator's asymptotic phase function. For stochastic dynamical models, the usual definition of the iPRC breaks down, because in the presence of even small amounts of noise, the "asymptotic phase" of an oscillator is no longer well defined. I will propose an alternative approach to redefining the asymptotic phase of a stochastic oscillator, in a way that is consistent across both the stochastic and deterministic settings. As examples, I will consider a heteroclinic oscillator that lacks a well defined deterministic phase [1] and a hybrid jump Markov process model channel noise in a conductance based single neuron model [2]. Based on joint work with Benjamin Lindner [3].

[1] K.M. Shaw, Y-M. Park, H.J. Chiel and P.J. Thomas 2012. SIAM J. Appl. Dyn. Sys., 11(1):350391. [2] D.F. Anderson, B. Ermentrout, and P.J. Thomas. in revision for J. Comp. Neurosci. [3] P.J. Thomas and B. Lindner, in preparation.

Speaker: **Troy, Bill** (University of Pittsburgh, USA)
Title: *Mathematical Predictions of Large Scale Neuronal Phenomena in the Brain: from Slices to Animal Brain to Humans*
Abstract: The Wilson-Cowan system, the Amari model, and the Pinto-Ermentrout (PE) equations, are widely studied mean field models of large scale neuronal activity. In this talk we show how the (PE) system provides qualitatively and quantitatively accurate predictions of brain patterns. First, we show

how rotating waves arise in the model when a parameter β is at low values. This prediction was non-trivial because spiral waves had not been observed experimentally, and were considered impossible to elicit by experimental neuroscientists. Our prediction was tested and fully confirmed in rat brain slices and *in vivo* experiments. Next, when β increases past a critical value, β^*, we show how regions of synchrony form and slowly migrate across a 2D region. We develop a formula to predict the rate of migration, and show how our formula provides a quantitatively accurate prediction of the rate of migration of a seizure across the surface of the brain of a human subject. Our computational and theoretical analysis shows how brain activity can emerge in the model, from mathematical rest state to physiological rest state (baseline), to hypersynchronous activity, which is a hallmark of epileptic seizures.

Speaker: **Wallace, Edward** (The University of Chicago, USA)
Title: *Ribosome movement: Modeling and Data Analysis.*
Abstract: Ribosomes are the macromolecular machines that synthesize protein from an RNA template. Ribosome profiling sequencing of mRNA fragments protected by translating ribosomes in principle allows measurement of the rate of protein synthesis, at single-codon resolution, across an entire transcriptome. These data promise to vastly increase our understanding of the regulation and evolution of protein synthesis, and have been avidly analyzed for long-studied and novel signals of translation rate. Surprisingly, expected speed effects from codons and mRNA secondary structure appear weak or absent, while most variability in speed remains unexplained by known biological mechanisms. More problematically, different statistical methods used to analyze ribosome profiling data based on differing assumptions give incompatible results. We present a predictive model of ribosome movement, and measurement via ribosome profiling, with tunable parameters including sequencing coverage and multiple biases. Our results indicate the prematurity of conclusions that codon usage has little influence on translation speed.

Speaker: **Wilson, Hugh** (York University)
Title: *Stereopsis, Rivalry, and Binocular Contrast Summation: A Model Based on the Wilson-Cowan Equations.*
Abstract: Small orientation differences between the two monocular images produce a stereoscopic percept of surface slant, while much larger differences generate binocular rivalry. In addition, contrasts of the two monocular images combine non-linearly to generate a binocular contrast percept. I will develop a unified model of these processes based on the Wilson-Cowan equations with a few modest embellishments that have perceptual consequences. The resulting model fits available data, and it makes new predictions that have subsequently been verified. Finally, there is evidence that rivalry ensues at the point where the inter-occular orientation difference exceeds that existing in natural images.

Speaker: **Wolf, Fred** (Max-Planck-Institut für Dynamik und Selbstorganisation, Göttingen, Germany)
Title: *Putting the twist into the shift – symmetries in the architecture of the visual cortex.*
Abstract: Over the past 65 million years, the evolution of mammals led – in several lineages – to a dramatic increase in brain size. During this process, some neocortical areas, including the primary sensory ones, expanded by many orders of magnitude. The primary visual cortex, for instance, measured about a square millimeter in late cretaceous stem eutherians but in *homo sapiens* comprises more than 2000 mm^2. If we could rewind time and restart the evolution of large and large-brained mammals, would the network architecture of neocortical circuits take the same shape or would the random tinkering process of biological evolution generate different or even fundamentally distinct designs? In this talk, I will argue that, based on the consolidated mammalian phylogenies available now, this seemingly speculative question can be rigorously approached using a combination of quantitative brain imaging, computational, and dynamical systems techniques. Our studies on visual cortical circuit layout in a broad range of eutherian species indicate that neuronal plasticity and developmental network self-organization have restricted the evolution of neuronal circuitry underlying orientation columns to a few discrete design alternatives. Our theoretical analyses predict that different evolutionary lineages adopt virtually identical circuit designs when using only qualitatively similar mechanisms of developmental plasticity.