MATHEMATICAL NEUROSCIENCE, MATH 577, Spring 2018

Instructor: Janek Wehr

Prerequisites: Advanced undergraduate Analysis and Ordinary Differential Equations. Math 425 and 355 will be more than enough.

To first approximation, brain is an electrical network. We (and our animal cousins) sense, react and think electrically or, more precisely, electrochemically. Elements of the brain activity can be modeled using differential equations, resembling those used to describe electrical circuits in physics. The underlying mathematics is simple—just ordinary differential equations—and yet the range phenomena it can describe is very rich. This is because one uses *systems* of equations and the equations are *nonlinear*. And, as the parameters in the systems of nonlinear equations change values, the systems undergo *bifurcations*. Mathematical models of brain's electrical activity which arise in this way are recently under intense study by neural scientists and mathematicians. Spikes, bursts, excitations, rhythms, synchronization—all these phenomena can be captured by the theory of nonlinear oscillations in bifurcating ODE systems. This course is an introduction to this beautiful, dynamically (pun *intended*) developing field of mathematical biology. No prior knowledge of bifurcation theory is necessary—just basic ordinary differential equations. The course will be accessible to advanced undergraduate students. The requisite dynamical systems background will be introduced as needed. I am aiming at a balance between mathematics and neurobiology, so bifurcation theory of vector fields will be discussed in some detail, not only applied to neural circuits. Still, it is neuroscience that is the main motivation behind the course. If you have any questions, please contact me at wehr@math.arizona.edu.

See you in January!

Literature

• Neuroscience

E. M. Izhikevich: Dynamical Systems in Neuroscience. The Geometry of Excitability and Bursting. MIT Press 2010. This will be the main text.

H. R. Wilson: Spikes, Decisions and Actions. Dynamical Foundations of Neuroscience. Oxford University Press 1999

A. Scott: Neuroscience. A Mathematical Primer. Springer 2002

• Dynamical systems and bifurcation theory

S. Strogatz: Nonlinear Dynamics and Chaos: With Applications to Physics, Biology, Chemistry, and Engineering. Westview Press 2014

J. Guckenheimer, P. Holmes: Nonlinear Oscillations, Dynamical Systems, and Bifurcations of Vector Fields. Springer 2002

V. I. Arnold: Geometrical Methods in the Theory of Ordinary Differential Equations. Springer 2012