

MATHEMATICS DEPARTMENT
North Carolina State University

DIFFERENTIAL EQUATIONS SEMINAR

Wednesday, January 25, 2006
3:00 p.m. 330 Harrelson Hall

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“The dynamic structure underlying subthreshold oscillatory activity and the onset of spikes in a model of medial entorhinal cortex stellate cells”

The study of rhythmic activity in various areas of the brain has been the object of many experimental and theoretical investigations. This talk concerns rhythmic oscillatory activity at theta frequencies (8–12 Hz) in the medial entorhinal cortex (MEC), which is the interface between the neocortex and the hippocampus, and plays an important role in some forms of learning and memory. Stellate cells (SCs), the main cell type in MEC layer II, display complex mixed-mode oscillatory (MMO) patterns (at theta frequencies) in which both subthreshold oscillations (STOs) and spikes coexist. These experimental results have been reproduced, via simulations, using biophysical models of SCs. These models consist of a multiscale system of nonlinear, high-dimensional, ordinary differential equations describing the evolution of voltage and other biophysical variables. A quantitative investigation, beyond simulations, on how the interaction between the participating SC's currents creates time scales that allow the cell to fire at theta frequencies has been difficult, mainly due to the complexity of the models and the lack of appropriate tools to deal with them. In this talk we answer some of the relevant mechanistic questions. We show that, during the interspike interval (ISI) where STOs are generated, the SC seven-dimensional model can be reduced

to a three-dimensional one, with two well-differentiated time scales. Using dynamical systems arguments we provide a mechanism for generations of STOs. This mechanism is based on a “canard structure,” in which relevant trajectories stay close to repelling manifolds for a significant interval of time. We also show that the transition from subthreshold oscillatory activity to spiking (“canard explosion”) is controlled in the ISI by the same structure. A similar mechanism is invoked to explain why noise increases the robustness of the STO regime.

Graduate students are invited to attend.

Dr. Rotstein is a candidate for a faculty position.

Tea will be served in HA 243 at 4:00 p.m.