WORKSHOP
Mathematical Neuroscience
September 16 – 19, 2007

Synchronous transitions between up and down states in a network model of spontaneous activity

Nestor Parga
Departamento de Física Teórica C-XI
Universidad Autónoma de Madrid
Ciudad Univérsítaria de Cantoblanco
28049 Madrid
SPAIN
nestor.parga@uam.es

Abstract

Neural activity in the absence of sensory stimulation can be structured with, in some cases, the membrane potential making spontaneous transitions between two different levels called up and down states. These transitions have been observed in a variety of systems and conditions: during slow-wave sleep, in the primary visual cortex of anesthetized animals, in the somatosensory cortex of unanesthetized animals during quiet wakefulness and in slices from ferrets and mice. At the network level, populations of neurons have been observed to make these transitions synchronously. The precise nature of the processes responsible for these phenomena is not known, although it is thought that synaptic activity and intrinsic neuron properties play an important role. Using a computational model we explore the interplay between intrinsic neuronal properties and synaptic fluctuations. Model neurons of the integrate-and-fire type were extended by adding a nonlinear membrane current. Networks of these neurons exhibit large amplitude synchronous spontaneous fluctuations that make the neurons jump between up and down states, thereby producing bimodal membrane potential distributions. The effect of sensory stimulation on network responses depends on whether the stimulus is applied during an up state or deeply inside a down state. External noise can be varied to modulate the network continuously between two extreme regimes in which it remains permanently in either the up or the down state.