Activity-dependent stochastic resonance in recurrent neuronal networks

VLADISLAV VOLMAN, UCSD

An important source of noise for neuronal networks is that of the stochastic nature of synaptic transmission. In particular, there can occur spontaneous asynchronous release of neurotransmitter at a rate that is strongly dependent on the presynaptic Ca2+ concentration and hence strongly dependent on the rate of spike induced Ca2+. Here it is shown that this noise can lead to a new form of stochastic resonance for local circuits consisting of roughly 100 neurons - a “microcolumn”- coupled via noisy plastic synapses. Furthermore, due to the plastic coupling and activity-dependent noise component, the detection of weak stimuli will also depend on the structure of the latter. In addition, the circuit can exhibit short-term memory, by which we mean that spiking will continue to occur for a transient period following removal of the stimulus. These results can be directly tested in experiments on cultured networks.

This research has been supported by the NSF-sponsored Center For Theoretical Biological Physics (grant nos. PHY-0216576 and PHY-0225630).