Stability of equilibria in an infinite dimensional network of theta neurons with time delay

Lavinia Florina Rodica Birdac

Abstract

We consider a network of identical all-to-all coupled theta neurons interacting through a synaptic current with distributed delay. Using the Watanabe–Strogatz transformation, we derive a reduced description of the system in terms of global variables.
In the thermodynamic limit of infinitely many neurons and under appropriate assumptions on the constants of motion, the dynamics reduces to a two-dimensional system with distributed delay, or equivalently to a complex delay differential equation describing the macroscopic behavior of the neuronal population.
Our results show that the introduction of delay can lead to significant changes in the dynamical behavior of the system, including delay-induced oscillations and changes in basin geometry.
The analytical results are complemented by numerical simulations illustrating how the delay reshapes the long-time dynamics of the neuronal population.