Thermodynamic Order Parameters and Statistical-Mechanical Measures for Characterization of the Burst and Spike Synchronizations of Bursting Neurons

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Abstract

We are interested in characterization of population synchronization of bursting neurons which exhibit both the slow bursting and the fast spiking timescales, in contrast to spiking neurons. Population synchronization may be well visualized in the raster plot of neural spikes which can be obtained in experiments. The instantaneous population firing rate (IPFR) $R(t)$, which may be directly obtained from the raster plot of spikes, is often used as a realistic collective quantity describing population behaviors in both the computational and the experimental neuroscience. For the case of spiking neurons, realistic thermodynamic order parameter and statistical-mechanical spiking measure, based on $R(t)$, were introduced in our recent work to make practical characterization of spike synchronization. Here, we separate the slow bursting and the fast spiking timescales via frequency filtering, and extend the thermodynamic order parameter and the statistical-mechanical measure to the case of bursting neurons. Consequently, it is shown in explicit examples that both the order parameters and the statistical-mechanical measures may be effectively used to characterize the burst and spike synchronizations of bursting neurons.