Dynamics of neuronal bursting

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The human brain is an endlessly fascinating organ from either the perspective of its structural complexity, originating in the astronomical number of neurons and connections, or the complexity of the tasks which it executes seemingly effortlessly, challenging science and engineering. Understanding the dynamics of individual neurons and neuronal networks is a key ingredient for understanding how the brain works.

Neurons can operate in a wide variety of regimes of electrical activity, which roughly could be described as rest states, sub-threshold oscillations, spiking, and bursting. The latter four types of regimes represent oscillatory activities. They could be periodic, quasi-periodic, or chaotic. The bursting regime is an oscillatory activity consisting of intervals of repetitive spiking separated by intervals of rest. It embodies a prominent manifestation of the complexity of neural dynamics based on ionic currents operating on different time scales. This special issue of the Journal of Biological Physics highlights approaches using biophysically accurate modeling, thorough analysis of the dynamics, and classification of the parameter regimes. A number of articles presented here apply bifurcation analysis to gain new insights into how neural systems operate. This assembly of articles substantiates the assertion that methods developed in the theory of dynamical systems are essential components of neuroscience research. In this context, I would also like to underscore prime advantages that are presented by the invertebrate nervous system, where single neurons can be identified by location, morphology, and activity from preparation to preparation and their dynamics can be analyzed individually. Three articles in this issue investigate the dynamics of specific neurons and neuronal networks in the medicinal leech.

This special issue spotlights the bursting regime and its role in the nervous system's functions and pathologies. Brain functions such as information processing, memory formation, and motor control frequently engage oscillatory dynamics of neurons. The functional and pathological roles of bursting regimes have been intensively investigated. Most clearly, it is the key regime for the control of rhythmic movements. Bursting activity is ubiquitously recorded in central pattern generators, oscillatory neuronal networks controlling motor

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behaviors such as breathing, locomotion, or heartbeat in invertebrates. Also, bursting has been widely observed in sleep and pathological brain states, like those associated with epilepsy syndromes. The main theme of this special issue is the elucidation of the roles of bursting regimes in the operation of the central nervous system under normal and pathological conditions. In conclusion, it clearly required expertise developed in different fields of science and to that end this issue deliberately gathered articles from neuroscientists with different backgrounds, ranging from physics, chemistry, and mathematics to ethology, who are interested in the dynamics of bursting regimes.

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