Enhancement and suppression of pulse propagation in a discrete Fitzhugh-Nagumo model subjected to a high-frequency stimulation

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We investigate a pulse propagation through a one-dimensional myelinated axon under action of a homogeneous high-frequency stimulation (HFS) current. The myelinated axon is modeled by a one-dimensional chain of diffusively coupled excitable elements described by the FitzHugh-Nagumo (FN) equations. Using the two-scale expansion method, we separate the fast and slow motions of the system and reduce the original problem to the solution of autonomous equations for the slow motion. By adopting asymptotic methods developed for the free FN system, we obtain various characteristics of the traveling pulse in the dependence of HFS amplitude. We show that the critical coupling strength, below which the pulse fails to propagate, has a non-monotonous dependence on the amplitude of HFS. This opens the possibility for HFS of a moderate amplitude to enhance the pulse propagation in the domain of small coupling strength, where the axon without stimulation demonstrates propagation failure. The HFS of sufficiently large amplitude always suppresses pulse propagation. The theoretical results are confirmed by numerical experiments with the original equations. Additionally, it is shown that the effect of enhancement of pulse propagation is more sensitive to noise than the effect of suppression of pulse propagation.

Key words: discrete FitzHugh-Nagumo model, myelinated axon, high-frequency stimulation, multiple scale method