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Can the ampere forces be a factor of the ion channels' lateral mobility? Mathematical modeling

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Abstract

© 2018 Russian Academy of Sciences. All rights reserved. Mathematical modeling methods are used to assess mutual shifts of the activated ion channels caused by the Ampère interaction of currents flowing through the channels that "float" freely in a lipid phase of chemically activated cell membrane. The analytical expression for shifts of two parallel conductors of finite length in a viscous medium due to the Amp6re attraction is obtained. Taking into account the lateral diffusion and the Ampère interaction of ion channels in a lipid matrix of a postsynaptic membrane we considered the dynamics of periodically activated solitary ion channels by one quantum of neurotransmitter ("spot") and the dynamics of clusters of ion channels of "spots" at periodical activation of a postsynaptic membrane by several synchronously released quanta of the neurotransmitter. The tendency of ion channels to form a united big cluster with preceding intermediate clustering with layout of ion channels and subclusters of them in the form of the triangular lattice is revealed. It is shown that due to weakness of the Ampere interaction this process is extremely slow by physiological measures and can have a physiological meaning only in the lipid bilayer areas with anomalously low viscosity and with essentially smaller lateral diffusion coefficient than is observed experimentally. Conditions favoring cluster formation may emerge in the presence of preformed large clusters of ion channels due to, for example, contact protein-protein interactions.

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Keywords

Ampère interaction of currents, Chemically activated membrane, Clustering, Ion channels, Quantum of neurotransmitter

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