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First principles of Ca^{2+}-signal decoding

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Abstract

Calcium (Ca^{2+}) is an important signaling molecule in cellular processes. In resting conditions, Ca^{2+} is actively exported from the cell resulting in very low cellular Ca^{2+} concentrations. External stimuli (as touch, damage, temperature change, ?) induce oscillations in cellular Ca^{2+} . These Ca^{2+}-oscillations activate or deactivate proteins, which in turn modifies diverse cellular processes.

Coding and decoding of Ca^{2+}-signals is poorly understood. I approached this topic by describing the physico-chemical principles of the interaction of Ca^{2+} and proteins in mathematical terms. A characteristic differential equation type [$\frac{df}{dt} = A - B * f$] plays a dominant role in the decoding process [A and B depend on the Ca^{2+}-concentration in a non-linear manner]. Cellular modules that follow this equation type allow the readout of frequency and amplitude information from the Ca^{2+}-signal.

The problem that I would like to discuss with mathematicians is: In biology oscillations are exclusively approached with Fourier-analysis, which is based on periodic trigonometric functions. I do not find that this is an appropriate approach. The representation of the Ca^{2+}-signal as a sum of rectangular functions would be more appropriate. In this case A and B are constant (even though for short time intervals) and the equation $\frac{df}{dt} = A - B * f$? can be solved.

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