A Master Equation approach to the latency and amplification mechanisms in Limulus photoreceptors

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Bumps are the elementary excitatory events of the Limulus' ventral nerve photoreceptor membran following single photon absorption. The steps between Rhodopsin reactions and the beginning the bump-signal are unknown (1).

In this investigation we tested the stochastic properties of simple theoretical reaction models which can be applied to the latency and amplification mechanisms concerning bump generation. With master equation techniques we were able to perform the stochastic analysis of a previously discussed deterministic model in a slightly modified version (3). This model consists of a chain of simple decay reactions which pass to an enzymecascade eventually opening sodium-channels (light-channels). This causes the transient potential fluctuation of a bump.

The latency distribution can be calculated from the model analytically using first-passage-time methods in restricted master equations. The bumpheight distribution can be found by simulating the time development of the master equation numerically applying Gillespie's method (4).

With this approach we investigated under which conditions (adaptation niveaus) the bumpheight distribution alters its bimodal form to a simple convex or concave type. The results of this study can be combined with new experimental data (2).

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