www.elsevier.com/locate/yjtbi

An open-loop approach to calculate noise-induced transitions

Farzaneh Maleki, Attila Becskei

PII: S0022-5193(16)30422-2
DOI: http://dx.doi.org/10.1016/j.jtbi.2016.12.012
Reference: YJTBI8895

To appear in: *Journal of Theoretical Biology*

Received date: 25 April 2016
Revised date: 3 November 2016
Accepted date: 13 December 2016

Cite this article as: Farzaneh Maleki and Attila Becskei, An open-loop approacl to calculate noise-induced transitions, *Journal of Theoretical Biology* http://dx.doi.org/10.1016/j.jtbi.2016.12.012

An open-loop approach to calculate noise-induced transitions

Farzaneh Maleki, Attila Becskei*

Biozentrum, Computational and systems biology, University of Basel, 4056 Basel, Switzerland

*Corresponding author. attila.becskei@unibas.ch

Abstract

Bistability permits the co-existence of two distinct cell fates in a population of genetically identical cells. Noise induced transitions between two fates of a bistable system are difficult to calculate due to the intricate interplay between nonlinear dynamics and noise in bistable positive feedback loops. Here we opened multivariable feedback loops at the slowest variable to obtain the open-loop function and the fluctuations in the open-loop output. By the subsequent reclosing of the loop, we calculated the mean first passage time (MFPT) using the Fokker-Planck equation in good agreement with the exact stochastic simulation. When an external component interacts with a feedback component, it amplifies the extrinsic noise in the loop. Consequently, the open-loop function is shifted and the transition rates between the two states in the closed loop are increased. Despite this shift, the open-loop output reflects the system faithfully to predict the MFPT in the feedback loop. Therefore, the open-loop approach can help theoretical analysis. Furthermore, the measurement of the mean value, variance, and the reaction time-scale of the open-loop output permits the prediction of MFPT simply from experimental data, which underscores the practical value of the stochastic open-loop approach.

Keywords

Gene regulatory network, linear noise approximation, diffusion, deviant effect, Stratonovich.

~~Equation Section (Next)~~

1. Introduction

Transitions between two activity states represent a widespread phenomenon in biology (Biancalani et al., 2014; Pisarchik and Feudel, 2014; Thomas et al., 2014). Bistability in gene