

# Fluctuating barrier problem and BVP

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Please, do criticise and ask questions!

## Why?

- ion jumps and potential jumps
- MFPT
- external excitation
- gating
- resonance ion transitions

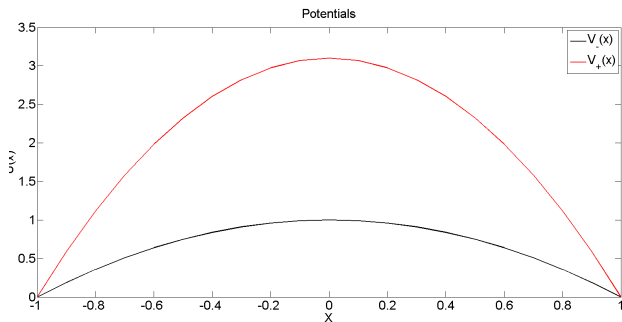
## The problem

“Resonant activation over a fluctuating barrier” (C.R. Doering, J.C. Gadoua, 1992)

Fluctuations of potential with exponential distribution.

$$V_- = U(x) = 1 - x^2$$

$$V_+ = (1 + \epsilon)U(x)$$



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Langevin eq:

$$\frac{dx}{dt} = -DV'(x, t) + \sqrt{2D}\xi(t),$$

Equation:

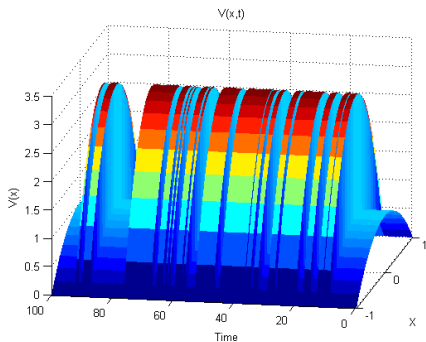
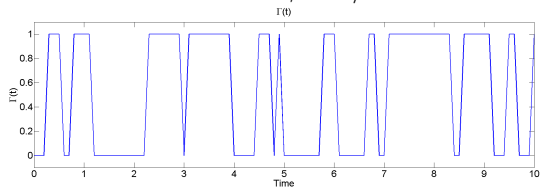
$$\frac{\partial}{\partial x} \begin{pmatrix} \rho_+ \\ \rho_- \end{pmatrix} = \begin{pmatrix} -\gamma + \frac{\partial}{\partial x} D(V'_+(x) + \frac{\partial}{\partial x}) & \gamma \\ \gamma & -\gamma + \frac{\partial}{\partial x} D(V'_-(x) + \frac{\partial}{\partial x}) \end{pmatrix} \begin{pmatrix} \rho_+ \\ \rho_- \end{pmatrix} \quad (4)$$

Boundary conditions:

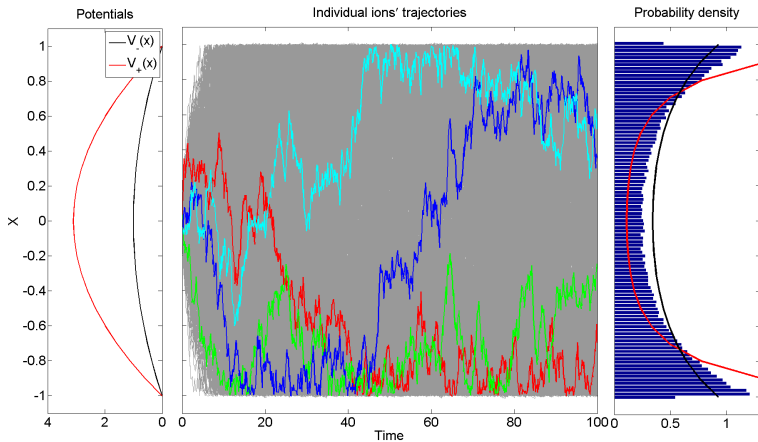
$$-\left(V'_\pm(x)\rho_\pm(x, t) + \frac{\partial \rho_\pm(x, t)}{\partial x}\right)\Big|_{x=\pm L} = 0, \quad (4.a)$$

Generation of exponentially distributed toggle times.

Parameters:  $D = 0.01$ ,  $\epsilon = 2.1$ ,  $\gamma = 1/0.3$



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## Function bvp5c in MATLAB

## New variables

$$y_1 = \rho_+, \quad y_2 = \rho'_+, \quad y_3 = \rho_-, \quad y_4 = \rho'_-$$

## Eq.(4) rewritten

$$y_1' = y_2,$$

$$y_2' = -(V_+'' y_1 + V_+' y_2) - \frac{\gamma}{D}(y_3 - y_1),$$

$$y_3' = y_4,$$

$$y_4' = -(V_-'' y_3 + V_-' y_4) - \frac{\gamma}{D}(y_1 - y_3),$$

## Boundary conditions:

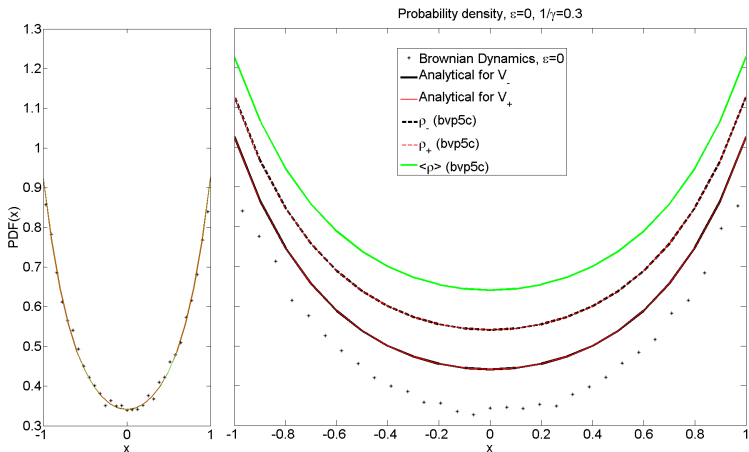
$$\left( V_+' y_1 + y_2 \right) \Big|_{x=\pm 1} = 0,$$

$$\left( V_+' y_3 + y_4 \right) \Big|_{x=\pm 1} = 0$$

## + Normalization

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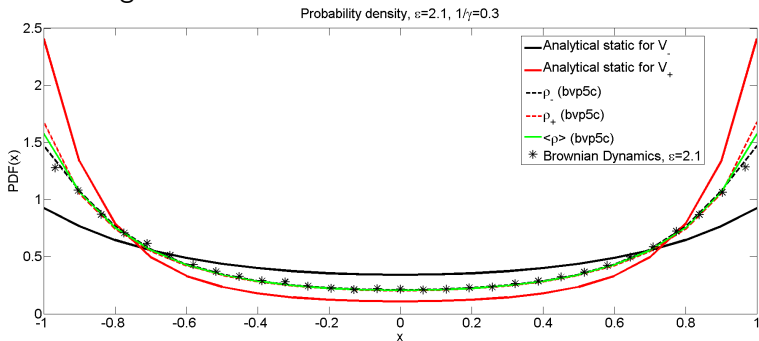
## Test: No fluctuations



Excellent matching

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## Fluctuating barrier



- Boundary conditions
- Probability current
- Current through the system

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