

## Accepted Manuscript

A framework towards understanding mesoscopic phenomena: Emergent unpredictability, symmetry breaking and dynamics across scales

Hong Qian, Ping Ao, Yuhai Tu, Jin Wang

PII: S0009-2614(16)30844-2  
DOI: <http://dx.doi.org/10.1016/j.cplett.2016.10.059>  
Reference: CPLETT 34283

To appear in: *Chemical Physics Letters*

Received Date: 29 June 2016  
Accepted Date: 21 October 2016

Please cite this article as: H. Qian, P. Ao, Y. Tu, J. Wang, A framework towards understanding mesoscopic phenomena: Emergent unpredictability, symmetry breaking and dynamics across scales, *Chemical Physics Letters* (2016), doi: <http://dx.doi.org/10.1016/j.cplett.2016.10.059>

This is a PDF file of an unedited manuscript that has been accepted for publication. As a service to our customers we are providing this early version of the manuscript. The manuscript will undergo copyediting, typesetting, and review of the resulting proof before it is published in its final form. Please note that during the production process errors may be discovered which could affect the content, and all legal disclaimers that apply to the journal pertain.



# A framework towards understanding mesoscopic phenomena: Emergent unpredictability, symmetry breaking and dynamics across scales

Hong Qian<sup>a</sup>, Ping Ao<sup>b</sup>, Yuhai Tu<sup>c</sup>, Jin Wang<sup>d,\*</sup>

<sup>a</sup>*Department of Applied Mathematics, University of Washington, Seattle, WA 98195 USA*

<sup>b</sup>*Shanghai Center for Systems Biomedicine, Shanghai Jiao Tong University, 200240, Shanghai, PRC*

<sup>c</sup>*IBM T.J. Watson Research Center, Yorktown Heights, NY 10598 USA*

<sup>d</sup>*Department of Chemistry and Physics, State University of New York, Stony Brook, NY 11794 USA.*

---

## Abstract

By integrating four lines of thoughts: symmetry breaking originally advanced by Anderson, bifurcation from nonlinear dynamical systems, Landau's phenomenological theory of phase transition, and the mechanism of emergent rare events first studied by Kramers, we introduce a possible framework for understanding *mesoscopic dynamics* that links (i) fast microscopic (lower level) motions, (ii) movements within each basin-of-attraction at the mid-level, and (iii) higher-level rare transitions between neighboring basins, which have slow rates that decrease exponentially with the size of the system. In this mesoscopic framework, the fast dynamics is represented by a rapidly varying stochastic process and the mid-level by a nonlinear dynamics. Multiple attractors arise as emergent properties of the nonlinear systems. The interplay between the stochastic element and nonlinearity, the essence of Kramers' theory, leads to successive jump-like transitions among different basins. We argue each transition is a dynamic symmetry breaking, with the potential of exhibiting Thom-Zeeman catastrophe as well as phase transition with the breakdown of ergodicity (e.g., cell differentiation). The slow-time dynamics of the nonlinear mesoscopic system

---

\*Corresponding author

*Email address:* jin.wang.1@stonybrook.edu (Jin Wang)

Download English Version:

<https://daneshyari.com/en/article/5378256>

Download Persian Version:

<https://daneshyari.com/article/5378256>

[Daneshyari.com](https://daneshyari.com)