

## WEINAN E

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### Education

Ph.D.	Mathematics	UCLA	1989
M.S.	Mathematics	Chinese Academy of Sciences	1985
B.S.	Mathematics	University of Science and Technology of China	1982

### Academic Positions

9/99-	Professor, Department of Mathematics and PACM, Associate Faculty Member of the Department of Operational Research and Financial Engineering, Princeton University
9/00-	Changjiang Visiting Professor, Peking University
5/14-8/18	Dean, Yuanpei College, Peking University
9/97-8/99	Professor, Courant Institute, New York University
9/94-8/97	Associate Professor, Courant Institute, New York University
9/92-8/94	Long Term Member, Institute for Advanced Study, Princeton
9/91-8/92	Member, Institute for Advanced Study, Princeton
9/89-8/91	Visiting Member, Courant Institute, New York University

### Awards and Honors

1993	Alfred P. Sloan Foundation Fellowship
1996	Presidential Early Career Award in Science and Engineering
1999	Feng Kang Prize in Scientific Computing
2003	ICIAM Collatz Prize, awarded by the 5th International Council of of Industrial & Applied Math.
2005	Elected Fellow of Institute of Physics
2009	Elected Fellow of Society of Industrial and Applied Mathematics
2009	The Ralph E. Kleinman Prize, Society of Industrial and Applied Mathematics
2011	Elected member of the Chinese Academy of Sciences
2012	Elected Fellow of the American Mathematical Society
2014	Theodore von Kármán Prize, Society of Industrial and Applied Mathematics

## Selected Lectures

- 12/2000 Invited Speaker, Current Developments in Mathematics, Harvard University.
- 6/2001 Invited Speaker, Annual Meeting of the American Physical Society, Division of Computational Physics, Boston.
- 8/2002 Invited Speaker, International Congress of Mathematicians, Beijing.
- 1/2003 Invited Hour Speaker, 109th Annual Meeting of the American Mathematical Society, Baltimore.
- 4/2004 Class of '27 Lecturer in Applied Mathematics, Rensselaer Polytechnic Institute.
- 8/2004 Plenary Speaker, Annual Meeting of the Chinese Society of Industrial and Applied Mathematics, Xiangtan, China.
- 3/2005 Speaker, School of Mathematics 75th Anniversary Celebration, Institute for Advanced Study.
- 7/2005 Invited Speaker, American Conference of Theoretical Chemistry, Los Angeles.
- 10/2005 Plenary Speaker, American Institute of Chemical Engineers Annual Meeting, Topical Conference on Multiscale Modeling, Cincinnati.
- 7/2006 Semi-Plenary Speaker, 7th World Congress on Computational Mechanics, Los Angeles.
- 9/2006 Invited Speaker, Annual Meeting of the American Chemical Society, Symposium on the Theory of Rare Events and Accelerated Dynamics, San Francisco.
- 7/2007 Invited Speaker, International Congress of Industrial and Applied Mathematics, Zurich.
- 3/2008 Invited Speaker, Eastern Section of the American Mathematical Society Meeting, New York.
- 5/2008 Distinguished Lecturer, University of Wisconsin, Madison.
- 6/2008 Goran Gustafsson Lecturer in Mathematics, Royal Institute of Technology, Sweden.
- 10/2008 Plenary Speaker, 4th International Conference on Multiscale Modeling of Materials, Tallahassee.
- 5/2009 Feng Kang Lecturer, 3rd SciCADE meeting, Beijing.
- 2/2012 Invited Speaker, March meeting of the American Physical Society, Division of computational physics, Boston.
- 6/2013 Plenary speaker, PRIMA Congress (Pacific Rim Mathematical Association), Shanghai, China.
- 10/2013 Plenary speaker, Annual meeting of the Chinese Mathematical Society, Taiyuan, China.
- 10/2013 Plenary speaker, Annual meeting of the Chinese Computer Science Society, Changsha, China.
- 10/2013 Plenary speaker, Annual meeting of the Chinese Computational Mathematics Society, Changsha, China.
- 4/2014 La Salle Lecturer, Brown University, Providence
- 6/2014 Maxwell Institute Colloquium Speaker, Edinburgh
- 7/2014 Plenary Speaker, Congress of the American Institute of Mathematical Sciences, Madrid.  
Plenary Speaker for the 1st (Beijing, 1998, declined), 2nd (Taiwan, 2001) and 4th (Hangzhou, 2007) International Congress of Chinese Mathematicians.

## Selected Synergistic Activities

**President** of the Chinese Computational Mathematics Society, 2014-

**Member** of the committee for selecting the Feng Kang Prize winners, 2005-2017.

**Member** of the committee for selecting the Collatz Prize winner for the 6th International Congress of Industrial and Applied Mathematics (ICIAM).

**Member** of the Scientific Advisory Committee for the 7th International Congress of Industrial and Applied Mathematics (ICIAM).

**Chairman** of the committee for selecting the Gibbs Lecturer, American Mathematical Society (2007-2008).

**Member** of the Program Committee for the 8th International Congress of Industrial and Applied Mathematics (ICIAM).

**Member** of the IMU committee for selecting the Gauss Prize, 2011-2014.

**Editorial committee** of the Journal American Mathematical Society, 2004-2014

**Editorial board** of Acta Mathematica Sinica, Acta Mathematicae Applicatae Sinica, Archive of Rational Mechanics and Analysis, Chinese Annals of Mathematics, Communications in Computational Physics, Communications in Contemporary Mathematics, Communications in Mathematical Sciences, Continuum Mechanics and Thermodynamics, Journal of Computational Mathematics, Journal of Mathematical Physics, Journal of Turbulence, etc.

**Past editorial board member** of J. of Statistical Physics, Nonlinearity, SIAM J. Multiscale Modeling and Simulation, etc.

**Co-organizer** (with Luis Caffarelli) of Park City Summer School in Mathematics, 1995.

**Organizer** of the special year on “Stochastic Partial Differential Equations and Turbulence Theory”, Institute for Advanced Study, 2002-2003.

**Co-organizer** (with Kaushik Bhattacharya) of the 4th SIAM Meeting on Material Science, Los Angeles, 2004.

**Member** of the Program Committee for the 2nd, 3rd and 5th SIAM Meeting on Material Science.

**Member** of the Organizing Committee, IPAM program on Multiscale Modeling, 2005.

**Member** of the Scientific Committee, 7th World Congress in Computational Mechanics, Los Angeles, 2006.

**Member** of the Organizing Committee, IMA special year on Mathematics and Chemistry, 2008-2009.

**Associate Faculty Member** of the Department of Operational Research and Financial Engineering, Princeton University.

## Advisors and Mentors

Advisor of master degree thesis: Professor Hongci Huang.

Advisor of doctoral degree thesis: Professor Bjorn Engquist.

Post-doctoral mentor: Professor Robert V. Kohn.

## Past Students and Post-docs

**Students:** Carlos Garcia, Yuan Lui, Xiaoming Wu, Yang Xiang, Weiqing Ren, Di Liu, Jerry Yang, Minxin Chen, Ming-Yih Wu, Dong Li, Congming Jin, Dongzhuo Zhou, Dan Hu, Xiang Zhou, Jianfeng Lu, Jingrun Chen, Lin Lin, Hao Shen, Cheng Tai, Qianxiao Li, Jiequn Han.

**Post-docs:** Felix Otto (1996-1997, now at University of Bonn), Cyrill Muratov (1997-1999, now at New Jersey Institute of Technology), Tim Schulze (1997-1999, now at University of Tennessee), Eric Vanden-Eijnden (1998-1999, now at Courant Inst), Zydrunas Gimbutas (1999-2000, now at NYU), Zhongyi Huang (2000-2002, now at Tsinghua University), Xiantao Li (2002-2004, now at Penn State University), Assyr Abdulle (2003-2004, now at EPFL), Jing Shi (2005-2006, now at Wayne State University), Xu Yang (2008-2010, now at Courant Institute), Amit Samanta (2010-2014, now at Lawrence Livermore Lab), Yajun Zhou (2011-2015), now at Peking University, Phil Trinh (2011-2012, now at Oxford University), Jianchun Wang (2013-2015), now at Nogaya University.

## Research Interests

Kohn-Sham equation and density functional theory, with application to electronic structure analysis

Theory and modeling of rare events with applications in chemistry, fluid mechanics and material sciences

Multiscale modeling

Stochastic partial differential equations

Mathematical theory of solids: from atomic to macroscopic scales

## Books

W. E, *Principles of Multiscale Modeling*, Cambridge University Press, 2011.

## Papers (upto 2018)

L. Wu, C. Ma and W. E, “How SGD Selects the Global Minima in Over-parameterized Learning: A Stability Perspective”, *NIPS*, 2018.

L. Zhang, J. Han, H. Wang, W. Saidi, R. Car and W. E, “End-to-end Symmetry Preserving Inter-atomic Potential Energy Model for Finite and Extended Systems”, *NIPS*, 2018.

Q. Li, L. Chen, C. Tai and W. E, “Maximum Principle Based Algorithms for Deep Learning”, *JMLR*, vol. 18, no. 165, pp. 1-29, 2018.

C. Ma, J.C. Wang and W. E, “Model reduction with memory and machine learning of dynamical systems”, *Comm. Comput. Phys.*, vol. 25, no. 4, pp. 947-962, 2019.

W. E, J. Han and Q. Li, “A Mean-Field Optimal Control Formulation of Deep Learning”, *Research in Mathematical Sciences*, vol. 6, no. 10, 2018.

L. F. Zhang, J. Han, R. Car, H. Wang and W. E, “Deep Potential Molecular Dynamics: A scalable model with the accuracy of quantum mechanics”, *Phys. Rev. Lett.*, vol. 120, no. 14, pp. 143001, 2018.

J. Han, A. Jentzen and W. E, “Solving high-dimensional partial differential equations using deep learning”, *Proc. Natl. Acad. Sci.*, vol. 115, no. 34, pp. 8505-8510, 2018.

J. Han, L. F. Zhang, R. Car and W. E, “Deep Potential: A General Representation of a Many-Body Potential Energy Surface”, *Comm. Comput. Phys.*, vol. 23, no. 3, pp. 629-639, 2018.

L. F. Zhang, H. Wang and W. E, “Reinforced dynamics for the enhanced sampling in large atomic and molecular systems. I. Basic Methodology”, *J. Chem. Phys.*, vol. 148, pp. 124113, 2018.

H. Wang, L. F. Zhang, J. Han and W. E, “DeePMD-kit: A deep learning package for many-body potential energy representation and molecular dynamics”, *Comput. Phys. Comm.*, vol. 228, pp. 178-184, 2018.

W. E, “A Proposal on Machine Learning via Dynamical Systems”, *Commun. Math. Stat.*, vol. 5, no. 1, pp.1-11, 2017.

W. E and B. Yu, “The Deep Ritz method: A deep learning-based numerical algorithm for solving variational problems”, *Comm. Math. Stats.*, vol. 6, no. 1, pp. 1-12, 2018.

W. E, J. Han and A. Jentzen, “Deep learning-based numerical methods for high-dimensional parabolic partial differential equations and backward stochastic differential equations”, *Comm. Math. Stats.*, vol. 5, no. 4, pp. 349-380, 2017.

- Q. Li, C. Tai and W. E, “Stochastic modified equations and the dynamics of stochastic gradient algorithms”, *JMLR*, vol. 20, no. 40, pp. 1-47, 2019.
- Q. Li, C. Tai and W. E, “Stochastic modified equations and adaptive stochastic gradient algorithms”, *International Conference of Machine Learning (ICML)*, 2017.
- W. E and Y. Wang, “Optimal convergence rates of the universal approximation error”, *Research in Mathematical Sciences*, vol. 4, no. 2, 2017.
- J. Han and W. E, “Deep learning approximation for stochastic control problems”, accepted, *NIPS Workshop on Deep Reinforcement Learning*, 2016.
- C. Tai and W. E, “Multi-scale adaptive representation of signals, I”, *JMLR*, vol.17, no. 140, pp. 1-38, 2016.
- W. E and Jianchun Wang, “A thermodynamic study of the two-dimensional pressure-driven channel flow”, *Discrete and Continuous Dynamical Systems*, vol. 36, no. 8, pp. 4349-4366, 2016.
- Q. Li, C. Tai and W. E, “Dynamics of stochastic gradient algorithms”, submitted to *Machine Learning*.
- C. Tai, T. Xiao, X. Wang and W. E, “Convolutional neural networks with low-rank regularization”, submitted to *ICLR*, 2016.
- C. Wang, Y. Wang, W. E and R. E. Schapire, “Functional Frank-Wolfe boosting for general loss functions”, submitted to *NIPS*.
- Q. Li and W. E, “The free action for non-equilibrium systems”, *J. Stat. Phys.*, vol. 161, no. 2, 300-325, 2015.
- A. Samanta, M. Tuckerman, T. Yu and W. E, “Microscopic mechanisms of equilibrium melting of a solid,” *Science*, vol. 346, no. 6210, pp. 729-732, 2014.
- A. Samanta, W. E, M. Chen, T. Yu and M. Tuckerman, “Sampling the saddle points on free energy landscapes,” *J. Chem. Phys.*, vol. 140, no. 16, 164109, 2014.
- W. E and H. Shen, “Mean field limit of a dynamical model of polymer systems”, *Science China Mathematics*, 2013, Volume 56, Issue 12, pp 2591–2598.
- W. E and H. Shen, “Exact renormalization group analysis of turbulent transport by the shear flow”, *Journal of Statistical Physics*, 153 (4), 553-571.
- L. Lin, S. Shao and W. E, “Efficient iterative method for solving the Dirac-Kohn-Sham density functional theory,” *J. Comput. Phys.*, vol. 245, pp. 205-217, 2013.
- W. E and J. Lu, “The Kohn-Sham equation for deformed crystals,” *Memoire of the American Math Society*, 2012.

- L. Lin, J. Lu, L. Ying and W. E, "Optimized local basis set for Kohn-Sham density functional theory," *J. Comput. Phys.*, vol. 231, no.13, pp. 4515-4529, 2012.
- W. E, X. Zhou and X. Cheng, "Subcritical bifurcations in spatially extended systems," *Nonlinearity*, vol. 25, no.3, pp. 761-779, 2012.
- L. Lin, J. Lu, L. Ying and W. E, "Adaptive local basis set for Kohn-Sham density functional theory in a discontinuous Galerkin framework I: Total energy calculation," *J. Comput. Phys.*, vol. 231, no. 4, pp. 2140-2154, 2012.
- A. Abdulle, W. E, B. Engquist and E. Vanden-Eijnden, "The heterogenous multiscale methods", *Acta Numerica*, vol. 21, pp. 1-87, 2012.
- L. Lin, C. Yang, J. Lu, L. Ying and W. E, "A fast parallel algorithm for selected inversion of structured sparse matrix with application to 2D electronic structure calculations," *SIAM J. Sci. Computing*, vol. 33, no.3, pp. 1329-1351, 2011.
- W. E and J. Lu, "The electronic structure of smoothly deformed crystals: Wannier functions and the Cauchy-Born rule," *Arch. Ration. Mech. Anal.*, vol. 199, pp. 407-433, 2011.
- W. E and X. Zhou, "The gentlest ascent dynamics," *Nonlinearity*, vol. 24, no. 6, pp. 1831-1842, 2011.
- W. E, J. Lu and X. Yang, "Effective Maxwell equations from time-dependent density functional theory", *Acta Math. Sinica*, vol. 27, pp. 339-368, 2011.
- W. E, J. Lu and X. Yang, "Asymptotic analysis of the quantum dynamics: The Bloch-Wigner transform and Bloch dynamics", *Acta. Appl. Math. Sinica.*, (25 July 2011), pp. 1-12.
- L. Lin, C. Yang, J. C. Meza, J. Lu, L. Ying and W. E, "SelInv – An algorithms for selected inversion of a sparse symmetric matrix", *ACM Transactions on Mathematical Software*, vol. 37, no. 4, pp. 40:1-40:19, 2011.
- W. E, T. Li and J. Lu, "Localized basis of eigen-subspaces", *Proc. Natl. Acad. Sci. USA*, vol. 109, pp. 1273-1278, 2010.
- W. E and E. Vanden-Eijnden, "The transition path theory and path-finding algorithms for the study of rare events," *Ann. Rev. Phys. Chem*, vol. 61, pp. 391-420, 2010.
- W. E and J. Lu, "The electronic structure of smoothly deformed crystals: Cauchy-Born rule for the nonlinear tight-binding model," *Comm. Pure Appl. Math.*, vol. 63, pp. 1432-1468, 2010.
- W. Ren, D. Hu and W. E, "Continuum theories for the moving contact line problem," *Phys. Fluids*, vol. 22, pp. 102103, 2010.
- X. Cheng, L. Lin, W. E, A-C. Shi, and P. Zhang, "Nucleation of Ordered Phases in Block Copolymers," *Phys. Rev. Lett.*, vol. 104, pp. 148301-148301-4, 2010.
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2010.

L. Lin, X. Cheng, W. E, A-C. Shi, and P. Zhang, "A numerical method for the study of nucleation of ordered phases," *J. Comput. Phys.*, vol. 229, no. 5, pp. 1797–1809, 2010.

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X. Zhou and W. E, "Study of noise-induced transitions in the Lorenz system using the minimum action method," *Comm. Math. Sci.*, vol. 8, pp. 341–355, 2010.

L. Lin, C. Yang, J. Lu, L. Ying and W. E, "A fast parallel algorithm for selected inversion of structured sparse matrices with application to 2D electronic structure calculation," *Lawrence Berkeley National Laboratory*. LBNL Paper LBNL-2677E. Retrieved from: <http://escholarship.org/uc/item/46q6w084>, 2010.

L. Lin, J. Lu, L. Ying and W. E, "Pole-based approximation of the Fermi-Dirac function," *Chin. Ann. Math.*, vol. 30B, pp. 729–742, 2009.

W. E, W. Ren, and E. Vanden-Eijnden, "A general strategy for designing seamless multiscale methods," *J. Comput. Phys.*, vol. 228, no. 15, 5437–5453, 2009.

C. Garcia-Cervera, J. Lu, Y. Xuan and W. E, "A Linear Scaling Subspace Iteration Algorithm with Optimally Localized Non-Orthogonal Wave Functions for Kohn-Sham Density Functional Theory," *Phys. Rev. B*, vol. 79, no. 11, pp. 115110–115110-13, 2009.

L. Lin, J. Lu, L. Ying, R. Car and W. E, "Fast algorithm for extracting the diagonal of the inverse matrix with application to the electronic structure analysis of metallic systems," *Comm. Math. Sci.*, vol. 7, pp. 755–777, 2009.

T. Li, J. Liu and W. E, "A probabilistic framework for network partition," *Phys. Rev. E*, vol. 80, no. 2, pp. 026106–026106-12, 2009.

L. Lin, J. Lu, R. Car and W. E, "Multipole representation of the Fermi operator with application to electronic structure analysis of metallic systems," *Phys. Rev. B*, vol. 79, no. 11, pp. 115133–115133-10, 2009.

W. E and D. Li, "On the crystallization of 2D hexagonal lattices," *Comm. Math. Phys.*, vol. 286, no. 3, pp. 1099–1140, 2009.

G. Wu, G. Lu, C.J. Garcia-Cervera, and W. E, "Density-gradient-corrected embedded atom method," *Phys. Rev. B*, vol. 79, pp. 035124–035124-8, 2009.

W. Gao and W. E "Orbital minimization with localization," *Discrete and Continuous Dynamical Systems*, vol. 23, no. 1-2, pp. 249–264, 2009.

W. E and D. Li, "The Andersen thermostat in molecular dynamics," *Comm. Pure Appl. Math.*, vol. 61, pp. 96–136, 2008.



C.J. García-Cervera, W. Ren, J. Lu, and W. E, “Sequential multiscale modeling using sparse representation,” *Comm. Comp. Phys.*, vol. 4, no. 5, pp. 1025–1033, 2008.

X. Zhou, W. Ren and W. E, “Adaptive minimum action method for the study of rare events,” *J. Chem. Phys.*, vol. 128, pp. 104111, 2008.

W. E, T. Li and E. Vanden-Eijnden, “Optimal partition and effective dynamics of complex networks,” *Proc. Natl. Acad. Sci. USA*, vol. 105, pp. 7907–7912, 2008.

T. Li, A. Abdulle and W. E, “Effectiveness of implicit methods for stiff stochastic differential equations,” *Comm. Comput. Phys.*, vol. 3, no. 2, pp. 295–307, 2008.

W. E, “Multiscale analysis of density functional theory,” Proceedings of the 6th International Congress of Industrial and Applied Mathematics, Zurich, 2007.

C. J. Garcia-Cervera, J. Lu and W. E, “Asymptotics-based sublinear scaling algorithms and applications to the study of electronic structure of materials,” *Comm. Math. Sci.*, vol. 5, pp. 990–1026, 2007.

S. Chen, W. E, Y. Liu and C.-W. Shu, “A discontinuous Galerkin implementation of a domain decomposition method for kinetic-hydrodynamic coupling multiscale problems in gas dynamics and device simulations,” *J. Comput. Phys.*, vol. 225, no. 2, pp. 1314–1330, 2007.

W. E, B. Engquist, X. Li, W. Ren and E. Vanden-Eijnden “Heterogeneous multiscale methods: A review,” *Comm. Comput. Phys.*, vol. 2, no. 3, pp. 367–450, 2007.

W. E and J. Lu, “Seamless multiscale modeling via dynamics on fiber bundles,” *Comm. Math. Sci.*, vol. 5, no. 3, pp. 649–663, 2007.

W. E and J. Lu, “The continuum limit and QM-continuum approximation of quantum mechanical models of solids,” *Comm. Math. Sci.*, vol. 5, no. 3, pp. 679–696, 2007.

W. E and J. Lu, “The Elastic Continuum Limit of the Tight Binding Model,” *Chinese Ann. Math. Ser. B*, vol. 28, no. 6, pp. 665–676, 2007.

W. E, D. Liu and E. Vanden-Eijnden, “Nested stochastic simulation algorithms for chemical kinetic systems with multiple time scales,” *J. Comput. Phys.*, vol. 221, no. 1, pp. 158–180, 2007.

W. E and P.B. Ming, “Cauchy-Born Rule and the Stability of Crystalline Solids: Dynamic Problems,” *Acta Math. Appl. Sin. Engl. Ser.*, vol. 23, no. 4, pp. 529–550, 2007.

W. E and P.B. Ming, “Cauchy-Born Rule and the Stability of Crystalline Solids: Static Problems,” *Arch. Rat. Mech. Anal.*, vol. 183, no. 2, pp. 241–297, 2007.

W. E, W. Ren, E. Vanden-Eijnden, “Simplified and improved string method for computing the minimum energy paths in barrier-crossing events,” *J. Chem. Phys.*, vol. 126, no. 16, pp. 164103–164103-8, 2007.

- W. Guo, T. P. Schulze and W. E, "Simulation of impurity diffusion in a strained nanowire using off-lattice KMC," *Comm. Comput. Phys.*, vol. 2, no. 1, pp. 164–176, 2007.
- D. Hu, P. Zhang and W. E, "Continuum theory of a moving membrane," *Phys. Rev. E*, vol. 75, no. 4, pp. 041605–041605-11, 2007.
- X. Li and W. E, "Variational boundary conditions for molecular dynamics simulations of crystalline solids at finite temperature: Treatment of the thermal bath," *Phys. Rev. B*, vol 76, no. 10, pp. 104107–104107-22, 2007.
- C.B. Muratov, E. Vanden-Eijnden, W. E, "Noise can play an organizing role for the recurrent dynamics in excitable media," *Proc. Natl. Acad. Sci.*, vol. 104, no. 3, pp. 702–707, 2007.
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- W. Ren and W. E, "Boundary conditions for the moving contact line problem," *Phys. Fluids*, vol. 19, pp. 022101–022101-15, 2007.
- X. Yue and W. E, "The local microscale problem in the multiscale modeling of strongly heterogeneous media: Effect of boundary conditions and cell size," *J. Comput. Phys.*, vol. 222, no. 2, pp. 556–572, 2007.
- W. E and P. Zhang, "A molecular theory of inhomogeneous liquid crystal flow and the small Deborah number limit," *Methods Appl. Anal.*, vol. 13, no. 2, pp. 181–198, 2006.
- W. E and E. Vanden-Eijnden, "Towards a theory of transition paths," *J. Stat. Phys.*, vol. 123, no. 3, pp. 503–523, 2006.
- X.-T. Li and W. E, "Variational boundary conditions for molecular dynamics simulation of solids at low temperature," *Comm. Comput. Phys.*, vol. 1, no. 1, pp. 135–175, 2006.
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- N. Choly, G. Lu, W. E and E. Kaxiras, "Multiscale Simulations in Simple Metals: A Density-Functional Based Methodology," *Phys. Rev. B*, vol. 71, no. 9, pp. 094101–094101-16, 2005.

W. E and B. Engquist, "The Heterogeneous Multi-Scale Method for Homogenization Problems," *Multiscale Methods in Sci. and Eng.*, pp. 89–110, *Lect. Notes in Comput. Sci. Eng.*, vol. 44, Springer, Berlin, 2005.

X.-T. Li and W. E, "Multiscale Modeling of the Dynamics of Solids at Finite Temperature," *J. Mech. Phys. Solids*, vol. 53, pp. 1650–1685, 2005.

W. E and X.-T. Li, "Multiscale Modeling of Crystalline Solids," *Handbook of Materials Modeling*, vol. A, pp. 1491–1506, Springer Netherlands, 2005.

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W. E, D. Liu and E. Vanden-Eijnden, "Analysis of multiscale methods for stochastic differential equations," *Comm. Pure Appl. Math.*, vol. 58, no. 11, pp. 1544–1585, 2005.

W. E and P.B. Ming, "Analysis of the local quasicontinuum method," *Frontiers and Prospects of Contemp. Appl. Math.*, pp. 18–32, *Contemporary Appl. Math.*, vol. 6, Higher Education Press, Beijing, 2005.

W. E, P.B. Ming and P.-W. Zhang, "Analysis of the heterogeneous multiscale method for elliptic homogenization problems," *J. Amer. Math. Soc.*, vol. 18, no. 1, pp. 121–156, 2005.

W. E, W. Ren and E. Vanden-Eijnden, "Finite temperature string method for the study of rare events," *J. Phys. Chem. B*, vol. 109, no. 14, pp. 6688–6693, 2005.

W. E, W. Ren and E. Vanden-Eijnden, "Transition pathways in complex systems: Reaction coordinates, iso-committor surfaces and transition tubes," *Chem. Phys. Lett.*, vol. 143, no. 1-3, pp. 242–247, 2005.

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C.B. Muratov, E. Vanden-Eijnden and W. E, "Self-induced stochastic resonance in excitable systems," *Phys. D*, vol. 210, no. 3-4, pp. 227–240, 2005.

W. Ren and W. E, "Heterogeneous multiscale method for the modeling of complex fluids and micro-fluidics," *J. Comput. Phys.*, vol. 204, no. 1, pp. 1–26, 2005.

S. Succi, W. E and E. Kaxiras, "Lattice Boltzmann Methods for Multiscale Fluid Problems," *Handbook of Materials Modeling*, Part B, pp. 2475–2486, Springer Netherlands, 2005.

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W. E and B. Engquist, "The heterogeneous multiscale method. Second Intl. Congress of Chinese Mathematicians," *Proc. of ICCM2001*, Taipei, pp. 57–74, New Studies in Advanced Mathematics, vol. 4, Intl. Press, 2004.

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