

JACOB FISH

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SYNOPSIS

Over the past 35 years Dr. Fish (64) has made many fundamental contributions to the field of multiscale computational science and engineering. Among the noteworthy contributions are: scale separation-free homogenization methods, reduced order multiscale methods, stochastic multiscale methods, temporal multiscale methods, methods accounting for dispersion and micro-inertia effects, coupling of multiple thermo-chemo-electro-mechanical processes at multiple spatial and temporal scales, multiscale enrichment methods, upscaling of discrete media, and multigrid and domain decomposition based multiscale methods. His research had a tremendous impact on industry. The *Multiscale Designer* software developed by the company he founded 15 years ago is considered to

be the gold standard in various industries with over 250 major customers in the aerospace, automotive, energy, electronics, manufacturing, consumer goods and health care sectors across the globe. His other noteworthy scientific contributions include but not limited to the *s*- method for adaptivity, algebraic multigrid and composite grid methods, integrated manufacturing-product design simulation methods, and most recently, development of the additive hypo-elasto-plasticity formulation based on so-called *kinetic logarithmic stress rate* that was proven to coincide with the multiplicative hyper-elasto-plasticity formulation, and thus enabling to extend a library of existing infinitesimal inelastic material models to large deformation regimes, that until now, not feasible by existing corotational frameworks.

Dr. Fish is the Robert A.W. and Christine S. Carleton Professor and Chair of the Department of Civil Engineering and Engineering Mechanics at Columbia University. He is a Founder and Director of Multiscale Science and Engineering Center originally at Rensselaer and now at Columbia University. He also serves as a

Director of Columbia University initiative for Computational Science and Engineering (iCSE) involving 65 faculty from all Engineering departments. Dr. Fish is a recipient of the 2021 John von Neumann Medal from the US Association for Computational Mechanics (USACM) for "sustained and seminal contributions to the field of multiscale computational science and engineering and for its major impact on industry", the 2018 Grand Prize from the Japan Society for Computational Engineering and Science (JSCES), the 2010 Computational Mechanics award from the International Association for Computational Mechanics (IACM) and the 2005 Ted Belytschko Medal from the USACM given in recognition for his contributions to multiscale science and engineering. Dr. Fish is a Fellow of American Academy of Mechanics (AAM), United States Association for Computational Mechanics (USACM) and the International Association for Computational Mechanics (IACM). For his "significant contributions to computational science and engineering" he received 2003 Rensselaer School of Engineering Research Award. Dr. Fish has written over 250 journal articles and book chapters, two of which have won the best paper awards. He is an author of several textbooks, including A First Course in Finite Elements and Practical Multiscale, both from Wiley. His introductory finite element textbook co-authored with Ted Belytschko has been integrated into curricula at more than 200 universities across the globe.

Dr. Fish is a two-term past President of the United States Association for Computational Mechanics and currently serves as the Vice-President for Americas of the International Association for Computational Mechanics. Dr. Fish is a Founder and Editor-in-Chief of the International Journal of Multiscale Computational Engineering, an Editor of the International Journal for Numerical Methods in Engineering and serves on the editorial board of several journals. Dr. Fish serves as a Chief Scientific Adviser to Altair, which recently acquired his company, Multiscale Design Systems. He served as the General Chair of the 13th World Congress in Computational Mechanics (WCCM) in NYC, which brought together over 3200 participants from academia, national laboratories, federal agencies, and industry.

EDUCATION

1989 Ph.D in Theoretical and Applied Mechanics, Northwestern University, Evanston, IL.

1985 M.S in Structural Mechanics, Technion - Israel Institute of Technology, Israel.

1982 B.S in Structural Engineering, Technion - Israel Institute of Technology, Israel.

PROFESSIONAL EXPERIENCE

2020-present Chair, Department of Civil Engineering and Engineering Mechanics, Columbia University.

2019-present Director, Computational Science and Engineering Initiative, Columbia University.

2011-present Robert A.W. and Christine S. Carleton Professor of Civil Engineering and Engineering Mechanics, Department of Civil Engineering and Engineering Mechanics, Columbia University.

2011-present Director, Multiscale Science and Engineering Center, Columbia University

2007-2015 Founder and President, Multiscale Design Systems (MDS), LLC.

2006-2010 Director, Multiscale Science and Engineering Center, Rensselaer.
2006-2010 The Rosalind and John J. Redfern Chaired Professor in Engineering, Mechanical, Aerospace and Nuclear Engineering and Civil and Environmental Engineering, Rensselaer.
1998-2010 Professor, Civil and Mechanical Engineering (joint), Rensselaer.
2001 Visiting Chair Professor, Ecole Normale Supérieure de Cachan, France.
1994 - 1998 Associate Professor, Civil and Mechanical (joint), Rensselaer.
1994 – 1998 Founder and President, Finite Element Oriented Solver (FEOS).
1989 - 1994 Assistant Professor, Civil Engineering, Rensselaer.
1984 - 1986 Research Engineer, Methods Development Group, Aircraft Industries, Israel.
1982 - 1984 Structural Engineer, Bukshpan-Harel, Civil Engineering Design Firm, Tel-Aviv, Israel.

HONORS AND AWARDS

John von Neumann Medal, US Association for Computational Mechanics, 2021.
Grand Prize, Japan Society for Computational Engineering and Science, 2019.
Computational Mechanics Award, International Association for Comp. Mechanics, 2010.
Fellow, American Academy of Mechanics, 2007.
Ted Belytschko Medal, US Association for Computational Mechanics, 2005.
Rensselaer School of Engineering Research Award, 2003.
Fellow, International Association for Computational Mechanics, 2001.
Fellow, US Association for Computational Mechanics, 2000.
Best Paper Award, ASME, International Computers in Engineering Conf., 1995.
Best Paper Award, AIAA/SDM Conference, 1993.
Young Investigator Award, National Science Foundation Presidential, 1992.
Presidential Award, 1978-1982, Technion - Israel Institute of Technology, 1978-1982.

EDITORSHIPS

Editor-in-Chief, International Journal Multiscale Computational Engineering, 2002-
Editor, International Journal for Numerical Methods in Eng., 2008-
Area Editor, Thermopedia, Begell House, 2008-
Editor, Bulletin of U.S. Association for Computational Mechanics, 1994 - 1997.
Associate Editor, Journal of Engineering Mechanics, 1999-2001
Editorial Board Member, International Journal for Numerical Methods in Eng., 2001-
Editorial Board Member, International Journal of Computational Eng. Science, 2003-
Editorial Board Member, Computer Methods in Applied Mech. and Eng., 2005-
Editorial Board Member, International Journal of Computational Methods, 2005-

MEMBERSHIPS/AFFILIATIONS

Vice President, International Association for Computational Mechanics, 2018-present.
President, U.S. Association for Computational Mechanics, 2002 – 2006.
Vice President, U.S. Association for Computational Mechanics, 2000-2002.
Secretary and Treasurer, U.S. Association for Computational Mechanics, 1998-2000.

Chair, ASCE Computational Mechanics Committee, 1999 - 2001.
Begell House Editorial Advisory Board, 2009-present
Member, National Research Council for Air and Ground Vehicle Technology, 2000-2004
Member, IUTAM Working Party Computational Fluid and Solid Mechanics, 2004-2012.
Member, U. S. National Committee on Theoretical and Applied Mechanics, 2006-2012.
External Reviewer, Sandia Computer Information Sciences Center, 2004.
Member, ASME, ASCE, AAM, ASEE, USACM, IACM

PUBLICATIONS

A. Books

1. [J. Fish and T. Belytschko, "A First Course in Finite Elements," John Wiley, 2007.](#)
2. J. Fish (ed), "Bridging the Scales in Science and Engineering," Oxford University Press, 2009
3. J. Fish, "Practical Multiscaling," John Wiley, 2013
4. F. Abdi, E. Clarkson, J. Fish, H. Baid, R. Miraj, Composite Materials Qualification, Begell House, 2021 (in print).
5. J. Fish, Z. Yuan, Y. Jiao, "Nonlinear Finite Element Method," Springer, to appear in 2021.

B. Book Chapters

6. T. Belytschko and J. Fish, "Numerical studies of two-dimensional shear banding with the spectral overlay on finite elements," eds. M. Kleiber and J. A. Konig, Antony Sawczuk Memorial Volume, (1990).
7. J. Fish, S. Markolefas, R. Guttal and P. Nayak, "On adaptive multilevel superposition of finite element meshes," *Adaptive Methods for Partial Differential Equations*, eds. J.E.Flaherty and M.S.Shephard, SIAM, (1994).
8. J. Fish and V. Belsky "Adaptive multi-grid method for a periodic heterogeneous medium in 1-D," IMA Volumes in Mathematics and its Applications: "Modeling, Mesh Generation, and Adaptive Numerical Methods for PDEs," eds. J. Flaherty, I.Babuska, W.D.Henshay, J.E. Uglier, P.A. Tezduyar, Springer Verlag, NY, Vol. 75, pp. 243-267, (1995).
9. J. Fish and V. Belsky "Adaptive multi-grid method for a periodic heterogeneous medium" The IMA Volumes in Mathematics and its Applications, Volume 75 Springer - Verlag, NY, pp. 243-266, 1995.
10. "Computational Advances in Modeling Composites and Heterogeneous Materials," edited by J. Fish. Special Issue of *Comp. Meth. Appl. Mech. Engng*, ELSEVIER, Vol. 127, 1999.

11. J. Fish and Q. Yu, "Computational Multiscale Fatigue Analysis and Life Prediction for Composite Structures," in *Modeling and Simulation Based Life Cycle Engineering*, ed. K. Chong and S. Saigal. Taylor & Francis/Spon Press, 11 New Fetter Lane, London, EC4P 4EE, 2001.

12. J. Fish, "Discrete to Continuum Multiscale Bridging," in *Multiscale Bridging in Molecular and Continuum Mechanics: Interaction of Time and Size from Macro to Nano*, Ed. G.C. Sih, Springer 2006.

13. M.S. Shephard, M.A. Nuggehally, B. Franz Dale, C.R. Picu and J. Fish, "Component Software for Multiscale Simulation" in *Bridging the Scales in Science and Engineering*, J. Fish (ed), Oxford University Press, 2009

14. J. Fish, "Multiscale Modeling and Simulation of Composite Materials and Structures," *Multiscale Methods in Computational Mechanics*, E. Ramm (ed.) Springer series, Lecture Notes in Applied and Computational Mechanics, Vol. pp. 215-231, 2011.

15. J. Fish and Z. Yuan, "N-scale Model Reduction Theory," in *Bridging the Scales in Science and Engineering*, J. Fish (ed), Oxford University Press, 2009

16. J. Fish, V. Filonova and Z. Yuan, Chapter 7: Multiscale Design: From Theory to Practice, in *Innovations in Biomolecular Modeling and Simulation*, series entitled Biomolecular Sciences published by The UK Royal Society of Chemistry, 2011

17. J. Fish, Towards General Purpose Design System for Composites, in *Multiscale Simulations and Mechanics of Biological Materials*, eds. S. Li and D. Qiang, John Wiley, 2013

18. V. Filonova, Y. Liu, J. Fish. Generalized Viscoplasticity Based on Overstress (GVBO) for Large Strain Single-Scale and Multiscale Analyses. In Ed. S. R. Idelsohn, *Computational Methods in Applied Sciences*, Springer Volume 33, 2014.

19. V. Filonova, Y. Liu, J. Fish. Chapter 6: A singlescale and multiscale models of polyurea and high-density polyethylene (HDPE) subjected to high strain rates. In *Elastomeric Polymers*, R. Barsoum (ed.), Elsevier 2014.

C. Refereed journal articles

20. T. Belytschko, J. Fish and B.E. Engelman, "A finite element with embedded localization zones," *Comp. Meth. Appl. Mech. Engng.*, Vol. 70, (1988), pp. 59 - 89.

21. T. Belytschko and J. Fish, "Embedded hinge lines for plate elements," *Comp. Meth. Appl. Mech. Engng.*, Vol. 76, No. 1, (1989), pp. 67-86.

22. T. Belytschko, J. Fish and A. Bayliss, "The spectral overlay on the finite element solutions with high gradients," *Comp. Meth. Appl. Mech. Engng.*, Vol 81, (1990), pp.71-89.

23. J. Fish and T. Belytschko, "Elements with embedded localization zones for large deformation problems," *Computers and Structures*, Vol. 30, No. 1/2, (1988), pp. 247-256.

24. J. Fish and T. Belytschko, "A finite element with a unidirectionally enriched strain field for localization analysis," *Comp. Meth. Appl. Mech. Engng.*, Vol. 78, No. 2, (1990), pp. 181-200.
25. J. Fish and T. Belytschko, "A general finite element procedure for problems with high gradients," *Computers and Structures*, Vol. 35, No. 4, pp.309-319, (1990).
26. J. Fish and T. Belytschko, "Stabilized rapidly convergent shell element with drilling degrees-of-freedom," *International Journal for Numerical Methods in Engineering*, Vol. 33, pp. 149-162 (1992).
27. J. Fish, "The s-version of the finite element method," *Computers and Structures*, Vol. 43, No. 3, pp. 539-547, (1992).
28. [J. Fish and S. Markolefas, "The s-version of the finite element method for multilayer laminates," *International Journal for Numerical Methods in Engineering*, Vol. 33, no. 5, pp. 1081-1105 \(1992\).](#)
29. J. Fish, "Hierarchical modeling of discontinuous fields," *Communications in Applied Numerical Methods*, Vol. 8, pp. 443-453, (1992).
30. M. S. Shephard, J. Fish and M. W. Beall, "Idealization control for the analysis of composite materials," *Computing Systems in Engineering*, Vol.3, pp. 443-456, (1992).
31. J. Fish and S. Markolefas, "Adaptive s-method for linear elastostatics," *Comp. Meth. Appl. Mech. Engng.*, Vol. 103, pp. 363-396, (1993).
32. J. Fish, N. Fares and A. Nath, "Micromechanical elastic cracktip stresses in a fibrous composite," *International Journal of Fracture*, Vol. 60, pp. 135-146, (1993).
33. J. Fish and A. Wagiman, "Multiscale finite element method for heterogeneous medium," *Computational Mechanics: The International Journal*, Vol. 12, pp. 1-17 (1993).
34. J. Fish and A. Nath, "Adaptive and hierarchical modeling of fatigue crack propagation," *International Journal for Numerical Methods in Engineering*, Vol. 36, pp. 2825- 2836 (1993).
35. J. Fish and S. Markolefas, R. Guttal and P. Nayak, "On adaptive multilevel superposition of finite element meshes," *Applied Numerical Mathematics*, Vol. 14, pp. 135-164, (1994).
36. J. Fish and S. Markolefas, "Adaptive global-local refinement strategy based on the interior error estimates of the h-method," *International Journal for Numerical Methods in Engineering*, Vol. 37, pp. 827-838, (1994).
37. J. Fish, P. Nayak, and M. H. Holmes, "Microscale Reduction Error Indicators and Estimators for a Periodic Heterogeneous Medium," *Computational Mechanics: The International Journal*, Vol. 14, pp. 1-16, (1994).

38. [J. Fish and V. Belsky, "Multigrid method for a periodic heterogeneous medium. Part I: Convergence studies for one-dimensional case," *Comp. Meth. Appl. Mech. Engng.*, Vol. 126, pp. 1-16, \(1995\).](#)
39. [J. Fish and V. Belsky, "Multigrid method for a periodic heterogeneous medium. Part 2: Multiscale modeling and quality control in multidimensional case," *Comp. Meth. Appl. Mech. Engng.*, Vol. 126, 17-38, \(1995\).](#)
40. [J. Fish, M. Pandheeradi and V. Belsky, "An efficient multilevel solution scheme for large scale nonlinear systems," *International Journal for Numerical Methods in Engineering*, Vol. 38, pp. 1597-1610, \(1995\).](#)
41. J. Fish and R. Guttal, "The p-version of the finite element method for shell analysis," *Computational Mechanics: The International Journal*, Vol. 16, pp. 1-13, (1995).
42. J. Fish V. Belsky and M. Pandheeradi, "Iterative and Direct Solvers for Interface Problems with Lagrange Multipliers," *International Journal of Computing Systems in Engineering*, Vol. 6, No. 3, pp. 261-273, (1995).
43. V. Belsky, M.W. Beall, J. Fish, M.S. Shephard, S. Goma, "Computer-Aided Multiscale Modeling Tools for Composite Materials and Structures," *International Journal of Computing Systems in Engineering*, Vol. 6, No. 3, pp. 213-223, (1995).
44. J. Fish and R. Guttal, "Recent advances in the p-version of the finite element method for shell analysis," *International Journal of Computing Systems in Engineering*, Vol. 6, No. 3, pp. 195-211, (1995).
45. M. S. Shephard, T. L. Sham, L. Y. Song, R. Garimella, H. F. Tersten, B. J. Lwo, Y. L. Le Coz, R.B. Aversion, and J. Fish, "Global/Local heat conduction and Thermomechanical Analyses of Multitude Modules," *Japanese Journal of Applied Mechanics*, (1996).
46. [J. Fish, P. Lei, V. Belsky, S. Goma, "Unstructured Multigrid Method for Shells," *International Journal for Numerical Methods in Engineering*, Vol. 39, pp. 1181-1197, \(1996\).](#)
47. [J. Fish, V. Belsky and M. Pandheeradi, "Composite grid method for hybrid systems," *Comp. Meth. Appl. Mech. Engng.*, Vol. 135, pp. 307-325, \(1996\).](#)
48. J. Fish, M. Panheeradi and V. Belsky, "Efficient Solution Schemes for Interface Problems," *Finite Elements in Analysis and Design*, Vol. 22, pp. 267-280, (1996).
49. J. Fish and R. Guttal, "The s-version of Finite Element Method for Laminated Composites," *International Journal for Numerical Methods in Engineering*, Vol. 39, pp. 3641-3662, (1996).
50. J. Fish and R. Guttal, "On the assumed strain formulation with selective polynomial order enrichment for p-version shells," *Computers and Structures*, Vol. 63, No.5. pp.899-913, (1997).

51. J. Fish, A. Suvorov and V. Belsky, "Hierarchical Composite Grid Method for Global-Local Analysis of Laminated Composite Shells," *Applied Numerical Mathematics*, Vol. 23, pp.241-258, (1997).
52. [J. Fish and V. Belsky, "Generalized Aggregation Multilevel Solver."](#) *International Journal for Numerical Methods in Engineering*, Vol. 40, pp.4341-4361, (1997).
53. J. Fish and R. Guttal, "Adaptive Solver for the p-version of Finite Element Method," *International Journal for Numerical Methods in Engineering*, Vol. 40, pp. 1767-1784, (1997).
54. J. Fish, K. Shek, M. Pandheeradi, and M.S. Shephard, "Computational Plasticity for Composite Structures Based on Mathematical Homogenization: Theory and Practice," *Comp. Meth. Appl. Mech. Engng.*, Vol. 148, pp. 53-73, (1997)
55. [J. Fish, Y. Qu and A. Suvorov, "Automated Adaptive Multilevel Solver,"](#) *Comp. Meth. Appl. Mech. Engng.*, Vol. 149, pp. 267-287, (1997).
56. [J. Fish, "Holistic approach for problems in heterogeneous media,"](#) *USACM Bulletin*, Vol. 10, No. 1, pp. 4-13, (1997).
57. [J. Fish and K.L. Shek, "Computational Aspects of Incrementally Objective Algorithms for Large Deformation Plasticity,"](#) *International Journal for Numerical Methods in Engineering*, Vol. 44, pp. 839-851, (1999).
58. [J. Fish and K. L. Shek, "Computational Plasticity and Viscoplasticity for Composite Materials and Structures,"](#) *Journal of Composites Part B*, (29B), pp. 613-619, (1998).
59. [J. Fish, J. LeMonds, and K. Shek, "Modeling and Simulation of Wrinkling in Compression Molding process of Fiber Reinforced Composites,"](#) *Journal of Engineering Mechanics*, Vol. 125, No. 8, pp. 951-955, (1999).
60. R. Collar, R. Wentorf, M.S. Shephard, J. Fish, Y.Qu, K. L. Shek, "Automated Analyses of Three-Dimensional Composite Unit Cells", *International Journal for Numerical Methods in Engineering*, (1999), in print.
61. [J. Fish and K. L. Shek, "Finite Deformation Plasticity of Composite Structures: Computational Models and Adaptive Strategies,"](#) *Comp. Meth. Appl. Mech. Engng.*, Vol. 172, pp. 145-174, (1999).
62. [R. Wentorf, R. Collar, M.S. Shephard, J. Fish, "Automated Modeling for Complex Woven Mesostructures,"](#) *Comp. Meth. Appl. Mech. Engng.*, Vol. 172, pp. 273-291, (1999).
63. [J. Fish, Y. Qu and A. Suvorov, "Towards robust two-level methods for indefinite systems,"](#) *International Journal for Numerical Methods in Engineering*, Vol. 45, pp. 1433-1456, (1999).

64. [J. Fish, Q. Yu and K. L. Shek, "Computational Damage Mechanics for Composite Materials Based on Mathematical Homogenization," *International Journal for Numerical Methods in Engineering*, Vol. 45, pp. 1657-1679, \(1999\).](#)
65. J. Fish and W. Chen, "On Accuracy, Stability and Efficiency of Implicit Methods with Incomplete Solution by Multilevel Methods," *International Journal for Numerical Methods in Engineering*, Vol. 46, pp. 253-273, (1999).
66. [R. Guttal and J. Fish, "Hierarchical Assumed Strain-Vorticity Shell Element With Drilling Degrees-of-Freedom," *Finite Elements in Analysis and Design*, Vol. 33, pp. 61-70, \(1999\).](#)
67. V. Korneev, J.E Flaherty, T. Oden, J. Fish, Hp-Version Additive Schwarz Algorithms on Triangular Meshes, I. *Mathematical Modelling*. No. 11, pp. 38-50, (2000).
68. V. Korneev, J.E Flaherty, T. Oden, J. Fish. Hp-Version Additive Schwarz Algorithms on Triangular Meshes, II. *Mathematical Modelling* No.12, pp. 28-37, (2000).
69. J. Fish and V. Korneev, "On Two-Level Methods Based on Aggregation for 3D Problems," *Mathematica*, (in Russian) Vol. 11, pp. 42-60, (2000).
70. [J. Fish and K. L. Shek, "Finite Deformation Plasticity Based on the Additive Split of the Rate of Deformation and Hyperelasticity," *Comp. Meth. Appl. Mech. Engng.*, Vol. 190, pp. 75-93, \(2000\).](#)
71. J. Fish and K.L. Shek, "Multiscale Analysis Of Large Scale Nonlinear Structures and Materials," *International Journal for Computational Civil and Structural Engineering*, Vol. 1. No. 1, pp. 79-90, (2000).
72. [J. Fish and K.L. Shek, "Multiscale Analysis for Composite Materials and Structures," *Composites Science and Technology: An International Journal*, Vol. 60, pp.2547-2556, \(2000\).](#)
73. [T. E. Giddings and J. Fish, "An Algebraic two-level preconditioner for asymmetric, positive-definite systems," *International Journal for Numerical Methods in Engineering*", Vol. 52, pp. 1443-1463, \(2001\).](#)
74. [J. Fish and Y. Qu, "Global Basis Two-Level Method for Indefinite Systems. Part 1: Convergence Studies," *International Journal for Numerical Methods in Engineering*, Vol. 49, pp. 439-460, \(2000\).](#)
75. [Y. Qu and J. Fish, ""Global Basis Two-Level Method for Indefinite Systems. Part 2: Computational Issues," *International Journal for Numerical Methods in Engineering*, Vol. 49, pp. 461-478, \(2000\).](#)
76. [J. Fish and W. Chen, "Higher-Order Homogenization of Initial/Boundary-Value Problem" Vol. 127, No. 12, pp. 1223-1230, *Journal of Engineering Mechanics*, \(2001\).](#)

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78. [W. Chen and J. Fish, "A Dispersive Model For Wave Propagation in Periodic Heterogeneous Media Based on Homogenization With Multiple Spatial and Temporal Scales," *Journal of Applied Mechanics*, Vol. 68, No. 2, pp. 153-161, \(2001\).](#)
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80. V. Korneev and J. Fish, "Two-level methods for spatial problems based on aggregation," *Izv. VUZ. Matematika*, Vol. 11, pp. 42-61, Allerton Press Inc., 18 West 27 st. NY, (2001).
81. [T. E. Giddings, Z. Rusak and J. Fish, "A Transonic small-disturbance model for the propagation of weak shock waves in heterogeneous gases," *International Journal of Fluids*, Vol. 429, pp. 255-281, \(2001\).](#)
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83. [J. Fish and Q. Yu, "Two-scale damage modeling of brittle composites" *Composites Science and Technology: An International Journal*, Vol. 61, pp.2215-2222, \(2001\).](#)
84. [J. Fish and W. Chen, "Uniformly Valid Multiple Spatial-Temporal Scale Modeling for Wave Propagation in Heterogeneous Media," *Mechanics of Composite Materials and Structures*, Vol. 8, pp. 81-99, \(2001\).](#)
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95. [J. Fish and W. Chen, "RVE Based Multilevel Method For Periodic Heterogeneous Media With Strong Scale Mixing," *Journal of Applied Mathematics*, Vol. 46, pp. 87-106, \(2003\).](#)
96. [J. Fish and C. Schwob, "Towards Constitutive Model Based on Atomistics," *Journal of Multiscale Computational Engineering*, Vol. 1 pp. 43-56, \(2003\).](#)
97. [M. Zeghal, E.L. Shamy, M.S. Shephard, R.Dobry, J. Fish, T. Abdoun, "Micro-Mechanical Analysis of Saturated Granular Soils," *Journal of Multiscale Computational Engineering*, Vol. 3, \(2003\).](#)
98. [J. Fish and W. Chen, "Modeling and Simulation of Piezocomposites," *Comp. Meth. Appl. Mech. Engng.*, Vol. 192, pp. 3211-3232, \(2003\).](#)
99. [J. Fish and W. Chen, "Discrete-to-Continuum Bridging Based on Multigrid Principles," *Comp. Meth. Appl. Mech. Engng.*, Vol. 193, pp. 1693-1711, \(2004\).](#)
100. [Z. Xu, R.C. Picu and J. Fish, "Higher Order Continuum Wave Equation Calibrated on Lattice Dynamics," *International Journal of Computational Engineering Science*, Vol. 5, No. 3, pp.557-574, \(2004\).](#)
101. [C. Oskay and J. Fish, "Fatigue Life Prediction using 2-Scale Temporal Asymptotic Homogenization," *International Journal for Numerical Methods in Engineering*, Volume 61, Issue 3, pp. 329-359 \(2004\).](#)
102. [H. Waisman, J. Fish, .R S. Tuminaro and J. Shadid, "The Generalized Global-Basis \(GGB\) Method" *International Journal for Numerical Methods in Engineering*, Vol. 61, No. 8, pp. 1243-1269, \(2004\)](#)
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