Prashant K. Jha

Research Associate

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POSITIONS

Research Associate Dec 2020 – present	Oden Institute for Computational Engineering and Sciences *The University of Texas at Austin, Austin, TX 78712, USA* <u>PI</u>: Prof. J. Tinsley Oden

▷ PAST POSITIONS

Adjunct Faculty Aug 2021 – Dec 2021	Department of Aerospace Engineering and Engineering Mechanics *The University of Texas at Austin, Austin, TX 78712, USA*
Adjunct Faculty Aug 2021 – Dec 2021	Department of Biomedical Engineering *The University of Texas at Austin, Austin, TX 78712, USA*
Peter O'Donnell Postdoctoral Fellow Aug 2019 – Nov 2020	Oden Institute for Computational Engineering and Sciences *The University of Texas at Austin, Austin, TX 78712, USA* <u>PI</u>: Prof. J. Tinsley Oden
Postdoctoral Fellow Oct 2016 – Jul 2019	Department of Mathematics *Louisiana State University, Baton Rouge, LA 70803, USA* <u>PI</u>: Prof. Robert Lipton

EDUCATION

Ph.D. 2012 – 2016	Civil and Environmental Engineering *Carnegie Mellon University, Pittsburgh, PA 15213, USA* <u>Adviser</u>: Prof. Kaushik Dayal <u>Thesis</u>: Coarse graining of electric field interactions with materials
M.E. 2010 – 2012	Mechanical Engineering *Indian Institute of Science, Bengaluru, KA 560012, India* <u>Adviser</u>: Prof. Chandrashekhar S. Jog <u>Thesis</u>: A monolithic strategy for fluid-structure interaction in compressible flow
B.E. 2006 – 2010	Mechanical Engineering *Govt. Engineering College, Raipur, CG 492001, India*

TEACHING EXPERIENCES

COE 311K Fall 2021	Engineering Computation Department of Aerospace Engineering and Engineering Mechanics *The University of Texas at Austin, Austin, TX 78712, USA*
BME 313L Fall 2021	Introduction to Numerical Methods in Biomedical Engineering Department of Biomedical Engineering *The University of Texas at Austin, Austin, TX 78712, USA*

JOURNAL RESPONSIBILITIES

▷ JOURNAL EDITING

Associate Editor Jul 2021 – present	Journal of Peridynamics and Nonlocal Modeling (JPER) (link)
Topic Editor Aug 2021 – present	Journal of Open Source Software (JOSS) (link)

▷ JOURNAL REVIEWS

CMAME (15+ reviews), JMPS, SINUM, M3AS, MMS, JALCOM, IJMST, BMJ Open, Mathematical Reviews (AMS), PHYSA

EXPERTISE

▷ SKILLS

Continuum Mechanics; Multiphysics Modeling and Simulation; Numerical Methods for Differential Equations, Optimization, Algebraic System of Equations; Finite Element Analysis; Fracture Mechanics; Constitutive Modeling; Phase-field Methods; Continuum Mixture Theory; Uncertainty Quantification; Bayesian Inference; Optimal Experimental Design; Machine Learning

▷ PROGRAMMING LANGUAGES AND TOOLS

C and C++; MATLAB and OCTAVE; Python; Shell; Git; Docker

GRANTS

1. **MDACC-Oden-TACC** A mechanistic tumor growth model for HP MRI
   Sep 2020 – Mar 2022 PI: Fuentes (MD Anderson Cancer Center), co-PI: **Jha**
   $50k

MAJOR PROJECTS (* – ONGOING, ** – COMPLETED)

- *****Bayesian calibration and inverse problems in mechanics** (at UT Austin)
  - Proposed a Bayesian inference method for the calibration of PDE-based models; the method employs goal-oriented a-posteriori estimates of modeling error JhaOden-JCP-2022
  - Faster MCMC parameter sampling by utilizing computationally cheaper approximations of the error in QoIs
  - Enhancing the application of the neural operator to Bayesian inverse problems by computing correction to neural operator prediction CaoRoseberryJha-Residual-2022
  - Significantly improved performance when correcting the neural operator predictions (examples include nonlinear Poisson equation and hyperelasticity)
- *****Multiphysics modeling of tissue-scale tumor growth** (at UT Austin)
  - Developed a 3D-1D model of tumor growth and angiogenesis, coupling the evolution of tumors with the flow in tissue and vascular network Nonlin-2021, CMAME-2021
  - 1D Poiseuille flow model and Darcy's law to simulate the flow in a vascular network and tissue domain, respectively
  - Evolution of tumors, proteins, and drugs based on continuum mixture theory and phase-field method
- *****Optimal experimental design for Hyperpolarized (HP) MRI** (at UT Austin)
  - Determining HP scan parameters (design parameters) such as flip angles and repetition times is non-trivial due to the signal decay and instantaneous signal loss during a scan
  - Proposed a method based on mutual information to determine the optimal design parameters that increase the information content of data JhaFuentes-MRM-2022
  - Received a grant of $50k as a co-PI (D. Fuentes as PI) for the duration of Sep 2020 – Mar 2022
- *****High-fidelity mechanics model for granular media** (at UT Austin)
  - Discrete Element Method (DEM) based models are restricted to spherical particles and can not simulate particle breakage
  - Combined peridynamics (nonlocal theory of fracture) and DEM and proposed a novel high-fidelity model called PeriDEM that overcomes the limitations of DEM-based models JMPS-2021
  - Open-source software available on GitHub (PeriDEM)
- *****Relating peridynamics and classical linear elastic fracture mechanics (LEFM)** (at UT Austin and LSU, Baton Rouge)
  - Connecting LEFM and peridynamics is of great interest for the validation and broader integration of peridynamics
  - We showed that peridynamics satisfies the LEFM energy relation JhaLipton-IJFrac-2021, LiptonJha-Nonlin-2021LiptonJha-JPER-2019
  - In the absence of fracture, peridynamics approximates elastodynamics JhaLipton-IJNME-2018
  - Obtained a CFL-like stability condition for an explicit time discretization of peridynamics JhaLipton-IJNME-2018
- *****Numerical method and analysis of peridynamics theory of fracture in solids** (at LSU, Baton Rouge)
  - Implemented and studied numerical methods such as finite difference and finite element for peridynamics JhaLipton-SINUM-2018, JhaLipton-DCDSB-2021, JhaLipton-CMAME-2019
  - Showed that the numerical solution converges to the exact solution as expected (an important contribution as such results were not clearly established before our work)
- *****Multiscale modeling of electrical interaction in ionic solids** (at CMU, Pittsburgh)
  - Coulombic interactions are long-ranged, and it is challenging to integrate them with multiscale methods, e.g., Quasicontinuum (QC) method
  - Obtained a continuum limit approximation of Coulombic (electrostatic) interaction and utilized the limiting energy to develop a QC method with electrostatic interaction JhaMarshallKnapDayal-Multiscale, JhaDayal-ContinuumLimit, Jha-PhDThesis-2016
- *****Discrete-to-continuum limit of electrostatic interaction in nanostructures** (at CMU, Pittsburgh)
  - Performed a rigorous derivation of continuum limit of electrostatic interaction in nanostructures with rotational and translational symmetries JhaDayal-ContinuumLimit
  - Unlike in the case of 3D crystal structures, the limiting electrostatic energy in nanostructures is local
  - The limiting energy includes contributions from both the tangential and normal components of the dipole moment field; tangential components not present in the limiting energy obtained through dimensional reduction techniques
- *****Monolithic fluid-structure interaction (FSI) formulation** (at IISc, Bangalore)
  - Developed a monolithic arbitrary Lagrangian-Eulerian (ALE) formulation for FSI problems
  - Compressible fluid and nonlinear solid undergoing large deformation
  - Mapped the Navier-Stokes equations for compressible fluid to the reference configuration
  - Developed energy-conserving time discretization and finite element spatial discretization of nonlinear coupled partial differential equations

Publications [Google Scholar]

▷ **Published**

1. P. K. **Jha** and R. Lipton, "Numerical analysis of nonlocal fracture models in holder space," SIAM Journal on Numerical Analysis, vol. 56, no. 2, pp. 906–941, 2018.

2. P. K. **Jha** and R. Lipton, "Numerical convergence of nonlinear nonlocal continuum models to local elastodynamics," International Journal for Numerical Methods in Engineering, vol. 114, no. 13, pp. 1389–1410, 2018.

3. R. Lipton, E. Said, and P. K. **Jha**, "Free damage propagation with memory," Journal of Elasticity, vol. 133, no. 2, pp. 129–153, 2018.

4. R. P. Lipton, R. B. Lehoucq, and P. K. **Jha**, "Complex fracture nucleation and evolution with nonlocal elastodynamics," Journal of Peridynamics and Nonlocal Modeling, vol. 1, no. 2, pp. 122–130, 2019.

5. P. K. **Jha** and R. Lipton, "Numerical convergence of finite difference approximations for state based peridynamic fracture models," Computer Methods in Applied Mechanics and Engineering, vol. 351, pp. 184–225, 2019.

6. P. Diehl, P. K. **Jha**, H. Kaiser, R. Lipton, and M. Lévesque, "An asynchronous and task-based implementation of peridynamics utilizing hpx—the c++ standard library for parallelism and concurrency," SN Applied Sciences, vol. 2, no. 12, pp. 1–21, 2020.

7. P. K. **Jha** and R. Lipton, "Finite element convergence for state-based peridynamic fracture models," Communications on Applied Mathematics and Computation, vol. 2, no. 1, pp. 93–128, 2020.

8. P. K. **Jha** and R. P. Lipton, "Kinetic relations and local energy balance for lefm from a nonlocal peridynamic model," International Journal of Fracture, vol. 226, no. 1, pp. 81–95, 2020.

9. P. K. **Jha**, L. Cao, and J. T. Oden, "Bayesian-based predictions of covid-19 evolution in texas using multispecies mixture-theoretic continuum models," Computational Mechanics, vol. 66, no. 5, pp. 1055–1068, 2020.

10. P. K. **Jha**, P. S. Desai, D. Bhattacharya, and R. Lipton, "Peridynamics-based discrete element method (peridem) model of granular systems involving breakage of arbitrarily shaped particles," Journal of the Mechanics and Physics of Solids, vol. 151, p. 104376, 2021.

11. R. P. Lipton and P. K. **Jha**, "Nonlocal elastodynamics and fracture," Nonlinear Differ. Equ. Appl. 28, vol. 23, 2021.

12. P. K. **Jha** and R. Lipton, "Finite element approximation of nonlocal dynamic fracture models," Discrete & Continuous Dynamical Systems-B, vol. 26, no. 3, p. 1675, 2021.

13. M. Fritz, P. K. **Jha**, T. Köppl, J. T. Oden, and B. Wohlmuth, "Analysis of a new multispecies tumor growth model coupling 3d phase-fields with a 1d vascular network," Nonlinear Analysis: Real World Applications, vol. 61, p. 103331, 2021.

14. M. Fritz, P. K. **Jha**, T. Köppl, J. T. Oden, A. Wagner, and B. Wohlmuth, "Modeling and simulation of vascular tumors embedded in evolving capillary networks," Computer Methods in Applied Mechanics and Engineering, vol. 384, p. 113975, 2021.

15. D. A. Hormuth, C. M. Phillips, C. Wu, E. A. B. F. Lima, G. Lorenzo, P. K. **Jha**, A. M. Jarrett, J. T. Oden, and T. E. Yankeelov, "Biologically-based mathematical modeling of tumor vasculature and angiogenesis via time-resolved imaging data," Cancers, vol. 13, no. 12, 2021.

16. P. Gadikar, P. Diehl, and P. K. **Jha**, "Load balancing for distributed nonlocal models within asynchronous many-task systems," in 2021 IEEE International Parallel and Distributed Processing Symposium Workshops (IPDPSW), (Los Alamitos, CA, USA), pp. 669–678, IEEE Computer Society, jun 2021.

17. P. K. **Jha** and P. Diehl, "Nlmech: Implementation of finite difference/meshfree discretization of nonlocal fracture models," Journal of Open Source Software, vol. 6, no. 65, p. 3020, 2021.

18. P. K. **Jha** and J. T. Oden, "Goal-oriented a-posteriori estimation of model error as an aid to parameter estimation," Journal of Computational Physics, vol. 470, p. 111575, 2022.

19. P. K. **Jha**, J. Marshall, J. Knap, and K. Dayal, "Atomic-to-continuum multiscale modeling of defects in crystals with nonlocal electrostatic interactions," Journal of Applied Mechanics, vol. 90, 11 2022.

▷ **Under Review**

20. P. K. **Jha**, T. Breitzman, and K. Dayal, "Discrete-to-continuum limits of long-range electrical interactions in nanostructures," Preprint: https://www.math.cmu.edu/cna/Publications/publications2020/papers/20-CNA-020.pdf, 2020.

21. P. K. **Jha**, C. Walker, D. Mitchell, J. T. Oden, D. Schellingerhout, J. A. Bankson, and D. T. Fuentes, "Mutual-information based optimal experimental design for hyperpolarized 13c-pyruvate mri," Submitted for review. Preprint: https://arxiv.org/abs/2206.12509, June 2022.

22. L. Cao, T. O'Leary-Roseberry, P. K. **Jha**, J. T. Oden, and O. Ghattas, "Residual-based error correction for neural operator accelerated infinite-dimensional bayesian inverse problems," arXiv preprint arXiv:2210.03008, 2022.

▷ **Book Chapters and Reports**

23. P. K. **Jha** and R. Lipton, Well-Posed Nonlinear Nonlocal Fracture Models Associated with Double-Well Potentials, pp. 1417–1456. Cham: Springer International Publishing, 2019.

24. P. K. **Jha** and R. Lipton, Finite Differences and Finite Elements in Nonlocal Fracture Modeling: A Priori Convergence Rates, pp. 1457–1494. Cham: Springer International Publishing, 2019.

25. R. Lipton, E. Said, and P. K. **Jha**, <u>Dynamic Brittle Fracture from Nonlocal Double-Well Potentials: A State-Based Model</u>, pp. 1265–1291. Cham: Springer International Publishing, 2019.

26. R. Lipton, E. Said, and P. K. **Jha**, <u>Dynamic Damage Propagation with Memory: A State-Based Model</u>, pp. 1495–1523. Cham: Springer International Publishing, 2019.

PROFESSIONAL ACTIVITIES

▷ CONFERENCE ORGANIZATION
- With colleagues, organized (as the main organizer) a USACM thematic conference on computational oncology. Jan 2022. Conference site.
- Co-organized a minisymposium M19 on "Nonlocal models in mathematics and computation" at the SIAM TX-LA 3rd Annual Meeting. Oct 2020.

▷ MENTORING
- Co-mentored a student working on the development of distributed solver for a nonlocal diffusion equation. Google Summer of Code 2020. Related github repository. Summer 2020.

OPEN-SOURCED SOFTWARE
- **PeriDEM.** Implementation of high-fidelity model (PeriDEM, JMPS 2021) of granular media.
- **NLMech.** Peridynamics simulation library. (With P. Diehl).
- **BayesForSEIRD.** Bayesian calibration and validation of the SEIRD epidemic model. (With L. Cao).
- **Angiogenesis3D1D.** Angiogenesis and tumor growth using 3D-1D model. (With T. Köppl, A. Wagner, M. Fritz).

AWARDS AND ACHIEVEMENTS

1.	**GATE exam**	All India rank 31 (957/1000 score) in GATE-2010 exam	
	May 2010	*India*	
2.	**TA Award**	Best Teaching Assistant award for the graduate level finite-element course	
	May 2013	*Carnegie Mellon University, Pittsburgh, PA 15213, USA*	
3.	**Fellowship**	Peter O'Donnell Postdoctoral Fellowship (competitive, about 4 fellowships a year)	
	Aug 2019	*The University of Texas at Austin, Austin, TX 78712, USA*	

TRAVEL

1.	**Visit**	Institute for Mathematics and its Applications	
	Feb 2017 – May 2017	*University of Minnesota Twin Cities, Minneapolis, MN 55455, USA*	

TALKS

1. <u>Seminar</u>: *Coarse graining of electric field interactions with materials.* Mechanical Engineering Seminar, Indian Institute of Science, Bengaluru, India. Aug 2016.
2. <u>Seminar</u>: *Coarse graining of electric field interactions with materials.* Mechanical Engineering Seminar, Indian Institute of Technology, Chennai, India. Aug 2016.
3. <u>Seminar</u>: *Coarse graining of electric field interactions with materials.* AEM Mechanics Research Seminar, University of Minnesota Twin Cities, Minneapolis, USA. Mar 2017.
4. <u>Seminar</u>: *Numerical analysis of nonlocal fracture models.* IMA Postdoctoral Seminar, University of Minnesota Twin Cities, Minneapolis, USA. Apr 2017.
5. <u>Conference</u>: *Numerical analysis of nonlocal fracture models.* US National Congress on Computational Mechanics USNCCM14, Montreal, Canada. Jul 2017.
6. <u>Seminar</u>: *Finite element approximation of nonlocal fracture models.* Mathematics Department Applied Analysis Seminar, Louisiana State University, Baton Rouge, USA. Mar 2018.
7. <u>Seminar</u>: *Well-posedness of nonlocal fracture models and apriori error estimates of numerical approximations.* Mathematics Department Seminar, Indian Institute of Science, Bengaluru, India. May 2018.
8. <u>Conference</u>: *Free damage propagation with memory.* 13th World Congress in Computational Mechanics, New York, USA. Jul 2018.
9. <u>Conference</u>: *Convergence results for finite element and finite difference approximation of nonlocal fracture models.* SIAM TX-LA Annual Meeting, Baton Rouge, USA. Oct 2018.
10. <u>Seminar</u>: *Modelling fracture in solids using nonlocal interaction: A brief overview of Peridynamics.* Mechanical Engineering Seminar, Indian Institute of Technology, Delhi, India. Apr 2019.
11. <u>Conference</u>: *Convergence results for finite element and finite difference approximation of nonlocal fracture.* ICIAM 2019, Valencia, Spain. Presented by Dr. R. Lipton. Jul 2019.
12. <u>Conference</u>: *Numerical fracture experiments using nonlinear nonlocal models.* US National Congress on Computational Mechanics USNCCM15, Austin, USA. Jul 2019.
13. <u>Informal seminar</u>: *Numerical fracture experiments using nonlinear nonlocal models.* Oden Institute, The University of Texas at Austin, Austin, USA. Aug 2019.

14. <u>Seminar</u>: *A mechanistic tumor growth model for HP MRI.* Center for Computational Oncology Seminar, The University of Texas at Austin, Austin, USA. Sep 2020.
15. <u>Seminar</u>: *A mechanistic tumor growth model for HP MRI.* Civil and Environmental Engineering Seminar, Carnegie Mellon University, Pittsburgh, USA. Oct 2020.
16. <u>Seminar</u>: *Application of peridynamics to fracture in solids and granular media.* Special Mechanics Seminar, University of Houston, Houston, USA. Oct 2020.
17. <u>Conference</u>: *Application of peridynamics to fracture in solids and granular media.* SIAM TX-LA Annual Meeting 2020, USA. Oct 2020.
18. <u>Seminar</u>: *Application of peridynamics to fracture in solids and granular media.* MAE Seminar Series, University at Buffalo, Buffalo, USA. Oct 2020.
19. <u>Seminar</u>: *Modeling failure in solids and tissue-scale tumour growth via high-fidelity computational methodologies.* Department Seminar, Department of Computational and Data Science, Indian Institute of Science, Bengaluru, India. May 2021.
20. <u>Conference</u>: *Analysis and Application of Peridynamics to Fracture in Solids and Granular Media.* EMI 2021, USA. May 2021.
21. <u>Conference</u>: *Analysis and Application of Peridynamics to Fracture in Solids and Granular Media.* USNCCM 16, USA. Jul 2021.
22. <u>Seminar</u>: *High-fidelity mechanistic modeling of tumor growth at the tissue scale.* Babuška Forum, Oden Institute, The University of Texas at Austin, Austin, USA. Sep 2021.

KEY REFERENCES

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