

# 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*

PI: 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*

PI: Prof. J. Tinsley Oden

#### Postdoctoral Fellow

Oct 2016 – Jul 2019

Department of Mathematics

*Louisiana State University, Baton Rouge, LA 70803, USA*

PI: Prof. Robert Lipton

## EDUCATION

### Ph.D.

2012 – 2016

Civil and Environmental Engineering

*Carnegie Mellon University, Pittsburgh, PA 15213, USA*

Adviser: Prof. Kaushik Dayal

Thesis: Coarse graining of electric field interactions with materials

### M.E.

2010 – 2012

Mechanical Engineering

*Indian Institute of Science, Bengaluru, KA 560012, India*

Adviser: Prof. Chandrashekhar S. Jog

Thesis: 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), PHYSICA

## 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

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

## GRANTS

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

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

- **\*Bayesian calibration and uncertainty quantification** (at UT Austin)
  - Proposed a Bayesian inference scheme for the calibration of PDE-based models that utilizes goal-oriented a-posteriori estimates [JhaOden-JCP-2022](#)
  - Faster MCMC parameter sampling by utilizing computationally faster approximations of the error in QoIs
  - Modeling “model inadequacy” (correction) in a Bayesian inference in which the high-fidelity model is replaced with surrogate models (manuscript in preparation)
  - Correction is designed to enhance the application of neural network surrogates in Bayesian inference (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 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 Sep 2020 – Mar 2022
- **\*High fidelity model for granular media** (at UT Austin)
  - Existing models based on the Discrete Element Method (DEM) are restricted to spherical particles, and can not handle 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)
  - Establishing a connection between LEFM and peridynamics is of great interest for a wider integration of peridynamics to practical applications; further, such endeavors have potential to increase our understanding of fracture
  - We showed that peridynamics satisfies the LEFM energy relation [JhaLipton-IJFrac-2021](#), [LiptonJha-Nonlin-2021](#) [LiptonJha-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 (important contribution as such results were not clearly established prior to our work)
- **\*\*Multiscale modeling of electrical interaction in ionic solids** (at CMU, Pittsburgh)
  - Coulombic interaction is long-ranged and it’s integration with multiscale methods, e.g., Quasicontinuum method, is difficult
  - Obtained a continuum limit approximation of Coulombic (electrostatic) interaction and utilized the limiting energy to develop a Quasicontinuum method with electrostatic interaction [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

## ▷ PUBLISHED

1. 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.
2. 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.
3. 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.
4. R. Lipton, E. Said, and P. K. **Jha**, “Free damage propagation with memory,” *Journal of Elasticity*, vol. 133, no. 2, pp. 129–153, 2018.
5. 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.
6. 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.
7. 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.
8. 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.
9. 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.
10. 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.
11. 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.
12. R. P. Lipton and P. K. **Jha**, “Nonlocal elastodynamics and fracture,” *Nonlinear Differ. Equ. Appl.* 28, vol. 23, 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. Tinsley Oden, “Goal-oriented a-posteriori estimation of model error as an aid to parameter estimation,” *Journal of Computational Physics*, p. 111575, 2022.

## ▷ UNDER REVIEW

19. 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.
20. 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 <sup>13</sup>c-pyruvate mri,” Submitted for review. Preprint: <https://arxiv.org/abs/2206.12509>, June 2022.

## ▷ BOOK CHAPTERS AND REPORTS

21. 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.
22. P. K. **Jha** and R. Lipton, *Finite differences and finite elements in nonlocal fracture modeling: A priori convergence rates*, pp. 1–38. Cham: Springer International Publishing, 2018.
23. R. Lipton, E. Said, and P. K. **Jha**, *Dynamic brittle fracture from nonlocal double-well potentials: A state-based model*, pp. 1–27. Cham: Springer International Publishing, 2018.
24. R. Lipton, E. Said, and P. K. **Jha**, *Dynamic damage propagation with memory: A state-based model*, pp. 1–29. Cham: Springer International Publishing, 2018.

## 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

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

### TRAVEL

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| 1. <b>Visit</b><br>Feb 2017 – May 2017 | Institute for Mathematics and its Applications<br><i>University of Minnesota Twin Cities, Minneapolis, MN 55455, USA</i> |
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### TALKS

1. Seminar: *Coarse graining of electric field interactions with materials*. Mechanical Engineering Seminar, Indian Institute of Science, Bengaluru, India. Aug 2016.
2. Seminar: *Coarse graining of electric field interactions with materials*. Mechanical Engineering Seminar, Indian Institute of Technology, Chennai, India. Aug 2016.
3. Seminar: *Coarse graining of electric field interactions with materials*. AEM Mechanics Research Seminar, University of Minnesota Twin Cities, Minneapolis, USA. Mar 2017.
4. Seminar: *Numerical analysis of nonlocal fracture models*. IMA Postdoctoral Seminar, University of Minnesota Twin Cities, Minneapolis, USA. Apr 2017.
5. Conference: *Numerical analysis of nonlocal fracture models*. US National Congress on Computational Mechanics USNCCM14, Montreal, Canada. Jul 2017.
6. Seminar: *Finite element approximation of nonlocal fracture models*. Mathematics Department Applied Analysis Seminar, Louisiana State University, Baton Rouge, USA. Mar 2018.
7. Seminar: *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. Conference: *Free damage propagation with memory*. 13th World Congress in Computational Mechanics, New York, USA. Jul 2018.
9. Conference: *Convergence results for finite element and finite difference approximation of nonlocal fracture models*. SIAM TX-LA Annual Meeting, Baton Rouge, USA. Oct 2018.
10. Seminar: *Modelling fracture in solids using nonlocal interaction: A brief overview of Peridynamics*. Mechanical Engineering Seminar, Indian Institute of Technology, Delhi, India. Apr 2019.
11. Conference: *Convergence results for finite element and finite difference approximation of nonlocal fracture*. ICIAM 2019, Valencia, Spain. Presented by Dr. R. Lipton. Jul 2019.
12. Conference: *Numerical fracture experiments using nonlinear nonlocal models*. US National Congress on Computational Mechanics USNCCM15, Austin, USA. Jul 2019.
13. Informal seminar: *Numerical fracture experiments using nonlinear nonlocal models*. Oden Institute, The University of Texas at Austin, Austin, USA. Aug 2019.
14. Seminar: *A mechanistic tumor growth model for HP MRI*. Center for Computational Oncology Seminar, The University of Texas at Austin, Austin, USA. Sep 2020.
15. Seminar: *A mechanistic tumor growth model for HP MRI*. Civil and Environmental Engineering Seminar, Carnegie Mellon University, Pittsburgh, USA. Oct 2020.
16. Seminar: *Application of peridynamics to fracture in solids and granular media*. Special Mechanics Seminar, University of Houston, Houston, USA. Oct 2020.

17. Conference: *Application of peridynamics to fracture in solids and granular media*. SIAM TX-LA Annual Meeting 2020, USA. Oct 2020.
18. Seminar: *Application of peridynamics to fracture in solids and granular media*. MAE Seminar Series, University at Buffalo, Buffalo, USA. Oct 2020.
19. Seminar: *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. Conference: *Analysis and Application of Peridynamics to Fracture in Solids and Granular Media*. EMI 2021, USA. May 2021.
21. Conference: *Analysis and Application of Peridynamics to Fracture in Solids and Granular Media*. USNCCM 16, USA. Jul 2021.
22. Seminar: *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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**Prof. Kaushik Dayal**

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**Prof. Robert Lipton**

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**Prof. David T. Fuentes**

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