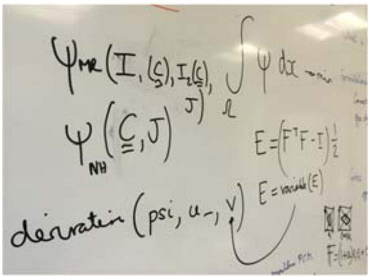
Multiscale methods for mechanics (3M)



Overview

The course will present an overview of recent developments, which will enable students to make informed choices in terms of discretization and model selection in solving numerical problems in mechanics. We will cover discretization strategies ranging from the standard finite element method, the smoothed finite element method, the extended finite element method, polygonal and virtual element methods, meshfree methods. The applications range between fracture of heterogeneous materials and biomedical simulations.

The intended learning outcomes of the course are such that the students will be:

- able to critically assess discretization schemes in mechanics
- able to implement simple error estimators for finite element methods
- familiar with basic multi-scale methods for fracture and their limitations
- able to follow basic literature in model error and model selection, in particular based on Bayesian inference

Course participants will learn these topics through lectures and hands-on numerical experiments.

Dates for the Course	**23rd May, 2016 to 3rd June, 2016**
Host Institute	**IIT Madras**
No. of Credits	**2**
Maximum No. of Participants	**50**
You Should Attend If…	▪ You are a senior under graduate student, postgraduate students or a faculty in engineering and applied mathematics. ▪ Engineers and researchers from industry, government organization and R&D laboratories. ▪ You are interested in numerical methods for engineering.
Course Registration Fees	The participation fees for taking the course is as follows: **Student Participants:** Rs.2000 **Faculty Participants:** Rs.6000 **Government Research Organization Participants**: Rs.10000 **Industry Participants:** Rs.20000 The above fee is towards participation in the course, the course material, computer use for tutorials and assignments, and laboratory equipment usage charges. **Mode of payment: Demand draft in favour of "Registrar, IIT Madras" payable at Chennai**
Accommodation	The participants may be provided with hostel accommodation, depending on the availability, on payment basis. Request for hostel accommodation may be submitted through the link: http://hosteldine.iitm.ac.in/iitmhostel

Course Faculty

Prof. Stéphane P.A. Bordas is an ERC starting fellow and Professor of Computational Mechanics at the University of Luxembourg and Cardiff University. He leads the Legato Team based jointly at the University of Luxembourg and at Cardiff University. He is an Adjunct Professor at the University of Western Australia. He heads the Computational Science Research Priority at the University of Luxembourg. Prof. Bordas' research focuses on method development, *a posteriori* error estimation, free boundary problems and cutting in soft tissue. Prof. Bordas is Editor of the Elsevier Book Series *Advances in Applied Mechanics* with Dr Daniel Balint http://legato-team.eu

Dr. Sundararajan Natarajan is a faculty member in the Department of Mechanical Engineering at IIT Madras. His research interests lie in the areas of computational solid mechanics and applied mathematics.

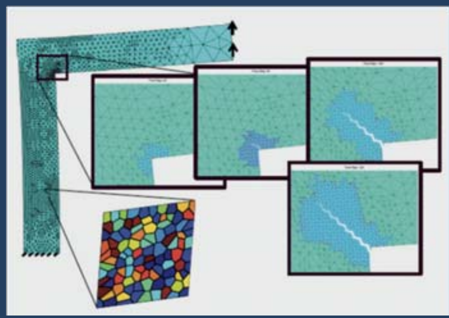
Preliminary Reading

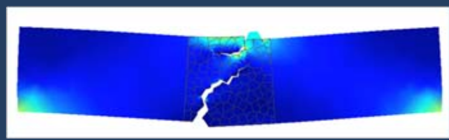
Akbari, A., Kerfriden, I., & **Bordas**, S. (2015). Error Controlled Adaptive Multiscale Method For Fracture Modelling in Polycrystalline materials. *Philosophical Magazine*. 95(28-30), pp 3328-3347 http://hdl.handle.net/10993/18262

Kerfriden, P., Gosselet, P., Adhikari, S., & **Bordas**, S. (2011). Bridging proper orthogonal decomposition methods and augmented Newton-Krylov algorithms: An adaptive model order reduction for highly nonlinear mechanical problems. *Computer Methods in Applied Mechanics & Engineering*, *200*(5-8), 850-866. http://hdl.handle.net/10993/14475

Hoang, K. C., Kerfriden, P., **Bordas**, S., & Khoo, B. C. (2015). An efficient goal-oriented sampling strategy using reduced basis method for parametrized elastodynamic problems. *Numerical Methods for Partial Differential Equations*. *31*(2), pp.575-608. http://hdl.handle.net/10993/15814

Kerfriden, P., Goury, O., Rabczuk, T., & **Bordas**, S. (2013). A partitioned model order reduction approach to rationalise computational expenses in nonlinear fracture mechanics. *Computer Methods in Applied Mechanics &*





Hybrid multi-scale approach to fracture of polycrystalline materials, Akbari, Kerfriden, Bordas. *Philosophical Magazine*, 2015

Course Coordinator

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Engineering, *256*, 169-188. http://hdl.handle.net/10993/10206

Kerfriden, P., Ródenas, J. J., & **Bordas**, S. (2013). Certification of projection-based reduced order modelling in computational homogenisation by the constitutive relation error. *International Journal for Numerical Methods in Engineering*. *97*(6), pp.395-422. http://hdl.handle.net/10993/10040

Kerfriden, P., Schmidt, K. M., Rabczuk, T., & **Bordas**, S. (2013). Statistical extraction of process zones and representative subspaces in fracture of random composites. *International Journal for Multiscale Computational Engineering*, *11*(3), 253-287. http://hdl.handle.net/10993/10066

Agathos, K., Chatzi, E., **Bordas**, S., & Talaslidis, D. (2015). A well-conditioned and optimally convergent XFEM for 3D linear elastic fracture. *International Journal for Numerical Methods in Engineering*. DOI: 10.1002/nme.4982 http://onlinelibrary.wiley.com/doi/10.1002/nme.4982/full http://hdl.handle.net/10993/19960

Bordas, S., González-estrada, O. A., Ródenas, J. J., Nadal, E., Kerfriden, P., & Fuenmayor, F. J. (2015). Locally equilibrated stress recovery for goal oriented error estimation in the extended finite element method. *Computers & Structures*. 152, pp.1-10. http://hdl.handle.net/10993/19509

Beex, L., Kerfriden, P., Rabczuk, T., & **Bordas**, S. (2014). Quasicontinuum-based multiscale approaches for plate-like beam lattices experiencing in-plane and out-of-plane deformation. *Computer Methods in Applied Mechanics & Engineering*, *279*, 348-378. http://hdl.handle.net/10993/17424

Talebi, H., Silani, M., **Bordas**, S., Kerfriden, P., & Rabczuk, T. (2013). A computational library for multiscale modeling of material failure. *Computational Mechanics*, 1-25. http://hdl.handle.net/10993/16054

Nguyen, V.-P., Anitescu, C., **Bordas**, S., & Rabczuk, T. (2015). Isogeometric analysis: an overview and computer implementation aspects. *Mathematics and Computers in Simulation*. 117, pp 89-116 http://hdl.handle.net/10993/21428

Duflot, M., & **Bordas**, S. (2008). A posteriori error estimation for extended finite elements by an extended global recovery. *International Journal for Numerical Methods in Engineering*, *76*(8), 1123-1138. http://hdl.handle.net/10993/15308

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Bordas, S., Nguyen, P. V., Dunant, C., Guidoum, A., & Nguyen-Dang, H. (2007). An extended finite element library. *International Journal for Numerical Methods in Engineering, 71*(6), 703-732. http://hdl.handle.net/10993/15234