



THE UNIVERSITY
of NORTH CAROLINA
at CHAPEL HILL

deal.II, IBAMR, and Cardinal: Scalable Software for Difficult Problems

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Overview

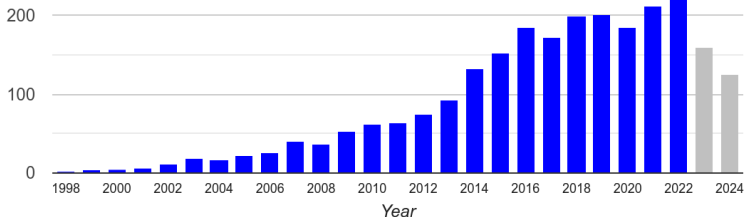
Topics

- deal.II
- IBAMR
- Cardinal

deal.II: Overview

- Large C++ library implementing adaptive finite elements
- Extraordinarily well-documented with an active community, classes, videos, examples, etc.
- Scalable to largest machines today (heterogeneous compute is WIP)
- Successfully used by students on laptops to solve dissertation-level problems
- Does not reinvent the wheel: relies on MPI, PETSc, Trilinos, p4est, and many others

deal.II: Community Impact



Known publications using deal.II. Total: **2462**. (Gray bars: Incomplete data.)

- I've been a principal developer since 2015 (one of fourteen)
- Large, quantifiable impact on science
- S-tier finite element library
- If you need to solve a PDE, deal.II can help

deal.II: Showcase: plate tectonics

- ASPECT: solve Stokes system at extreme scale (ten trillion DoFs) on Frontera (Gassmoeller et al)
- Answer fundamental rheological questions, planetary formation, plate techtonics
- Matrix-free geometric multigrid, scalable linear solvers and preconditioners

deal.II: Showcase: hypersonic flows

- ryujin: graph viscosity methods for hyperbolic conservation laws (Maier et al)
- Model

IBAMR: Overview

- Large C++ library with both finite differences (FDM) and finite elements (FEM)
- Scalable 2d and 3d implementations of common IB methods
- Major project, lead by Boyce Griffith here at UNC, to solve hard FSI problems, complex fluids, multiphase flows (Bhalla et al at SDSU)
- I have been a comaintainer since 2018

IBAMR: Some Applications

- Large C++ library with both finite differences (FDM) and finite elements (FEM)
- Scalable 2d and 3d implementations of common IB methods
- Major project, lead by Boyce Griffith here at UNC, to solve hard FSI problems, complex fluids, multiphase flows (Bhalla et al at SDSU)

Cardinal: IBAMR plus deal.II

- In-progress (unification of other projects)
- S-tier heart model (we have realistic valve dynamics!)
- Builds on deal.II's scalable FE infrastructure and IBAMR's IB and incompressible Navier-Stokes (INS) solvers