Spencer H. Bryngelson

Senior Postdoctoral Scholar | California Institute of Technology

spencer@caltech.edu +1(734)674-5501 bryngelson-research.com

Research experience

California Institute of Technology 2018–Present
Senior Postdoctoral Scholar (with Professor Tim Colonius) *Pasadena, CA*

- Created state-of-the-art models for the disperse flows central to targeted medical therapies
- Developed `MFC`, a parallel, multi-phase, and multi-scale flow solver for biophysical problems

Massachusetts Institute of Technology Summer 2019
Visiting Researcher (Professor Themis Sapsis) *Cambridge, MA*

- Developed low-order moment method for cavitating bubble population dynamics
- Leveraged Gaussian closures and recurrent neural networks for predicting flow statistics

Center for Exascale Simulation of Plasma-Coupled Combustion (XPACC) 2017–2018
Postdoctoral Researcher (Professors Carlos Pantano, Jonathan Freund, Daniel Bodony) *Urbana, IL*

- Developed a novel adjoint-based sensitivity analysis for flows with strong acoustics
- Orchestrated large-scale flow simulations for uncertainty quantification of multi-physics flows

University of Illinois at Urbana–Champaign 2013–2017
Graduate Research Fellow (Professor Jonathan Freund) *Urbana, IL*

- Developed novel stability and rheological analyses for biomicrofluidic device design
- Discovered buckling mechanism that prevents sickled cells from flowing efficiently

University of Michigan–Dearborn 2012–2013
Undergraduate Research Assistant (Professor Eric Ratts) *Dearborn, MI*

- Designed pressurized pipe flow system for heat-transfer analysis of multi-phase complex fluids

Education

University of Illinois at Urbana–Champaign

Doctor of Philosophy, Theoretical and Applied Mechanics (Advisor: Jonathan Freund) 2017
Master of Science, Theoretical and Applied Mechanics 2015
Graduate Degree Certificate, Computational Science and Engineering 2015

University of Michigan–Dearborn

Batchelor of Science, Mechanical Engineering, *with distinction* 2013
Batchelor of Science, Engineering Mathematics, *with distinction* 2013

Teaching experience

University of Illinois at Urbana–Champaign
Lecturer (Teaching Fellow) *Urbana, IL*

- Fundamentals of Fluid Dynamics (Junior Level) 2015

University of Michigan–Dearborn
Teaching Assistant *Dearborn, MI*

- Design and Analysis of Machine Elements (Junior Level) 2013
- Probability, Statistics, and Reliability in Design (Senior Level) 2012
- Statics and Mechanics of Materials (Sophomore Level) 2012

Publications

—— REFEREED JOURNAL PAPERS ——

1. T. Trummler, **S. H. Bryngelson**, K. Schmidmayer, S. J. Schmidt, T. Colonius, N. A. Adams, "Near-surface dynamics of a gas bubble collapsing above a crevice," under review *Journal of Fluid Mechanics*, arXiv: 1912.07022 (2020)
2. **S. H. Bryngelson**, K. Schmidmayer, V. Coralic, K. Maeda, J. Meng, T. Colonius, "MFC: An open-source high-order multi-component, multi-phase, and multi-scale compressible flow solver," under review *Computer Physics Communications*, arXiv: 1907.10512 (2020)
3. **S. H. Bryngelson**, A. Charalampopoulos, T. P. Sapsis, T. Colonius, "A Gaussian moment method and its augmentation via LSTM recurrent neural networks for the statistics of cavitating bubble populations," *International Journal of Multiphase Flow* **127**, 103262 (2020)
4. **S. H. Bryngelson**, T. Colonius, "Simulation of humpback whale bubble-net feeding models," *Journal of the Acoustical Society of America* **147**, 1126–1135 (2020)
5. K. Schmidmayer, **S. H. Bryngelson**, T. Colonius, "An assessment of multicomponent flow models and interface capturing schemes for spherical bubble dynamics," *Journal of Computational Physics* **402**, 109080 (2020)
6. **S. H. Bryngelson**, K. Schmidmayer, T. Colonius, "A quantitative comparison of phase-averaged models for bubbly, cavitating flows," *International Journal of Multiphase Flow* **115**, 137–143 (2019)
7. **S. H. Bryngelson**, F. Guéniat, J. B. Freund, "Irregular dynamics of cellular blood flow in a model microvessel," *Physical Review E* **100**, 012203 (2019)
8. **S. H. Bryngelson**, J. B. Freund, "Non-modal Floquet stability of capsules in large-amplitude oscillatory extensional flow," *European Journal of Mechanics B* **77**, 171–176 (2019)
9. **S. H. Bryngelson**, J. B. Freund, "Global stability of flowing red blood cell trains," *Physical Review Fluids* **3**, 073101 (2018)
10. **S. H. Bryngelson**, J. B. Freund, "Floquet stability analysis of capsules in viscous shear flow," *Journal of Fluid Mechanics* **852**, 663–677 (2018)
11. **S. H. Bryngelson**, J. B. Freund, "Capsule-train stability," *Physical Review Fluids* **1**, 033201 (2016)
12. **S. H. Bryngelson**, J. B. Freund, "Buckling and its effect on the confined flow of a model capsule suspension," *Rheologica Acta* **55**, 451-464 (2016)

—— REFEREED CONFERENCE PAPERS ——

1. M. Rodriguez, **S. H. Bryngelson**, S. Cao, T. Colonius, "A unified Eulerian multiphase framework for fluid-structure interaction problems including cavitation," *XXV International Conference of Theoretical and Applied Mechanics,* Milano, Italy (2020)
2. **S. H. Bryngelson**, T. Colonius, "Closure of phase-averaged bubbly, cavitating flow models," *XXV International Conference of Theoretical and Applied Mechanics,* Milano, Italy (2020)
3. **S. H. Bryngelson**, T. Colonius, "Phase- and mixture-averaged techniques for general bubbly flows," *33rd Symposium of Naval Hydrodynamics*, Osaka, Japan (2020)
4. **S. H. Bryngelson**, T. Colonius, "A comparison of ensemble- and volume-averaged bubbly flow models," *10th International Conference of Multiphase Flow*, Rio de Janeiro, Brazil (2019)
5. **S. H. Bryngelson**, J. B. Freund, "Buckling and the rheology of an elastic capsule suspension," *XXIV International Conference of Theoretical and Applied Mechanics,* Montreal, Canada (2016)

6. J. B. Freund, **S. H. Bryngelson**, "The stability of flowing trains of confined red blood cells," *XXIV International Conference of Theoretical and Applied Mechanics,* Montreal, Canada (2016)

—— OTHER PUBLICATIONS ——

1. **S. H. Bryngelson**, C. Pantano, D. Bodoney, J. B. Freund, "Adjoint-based sensitivity for flows with shocks," *XPACC Technical Report* (2018)
2. **S. H. Bryngelson**, "Stability and transition of capsule-flow systems," *Ph.D. Dissertation*, University of Illinois at Urbana–Champaign (2017)

Presentations

—— OTHER CONFERENCE TALKS ——

1. **S. H. Bryngelson**, T. Colonius, "A fast-integration-based model for polydisperse bubble cloud dynamics and their two-way-flow coupling," *Journal of the Acoustical Society of America* (2020)
2. **S. H. Bryngelson**, T. Colonius, "Annular and spiral bubble nets: A simulation-focused analysis of humpback whale feeding strategies," *Journal of the Acoustical Society of America* **146**, 4, 2771 (2019)
3. **S. H. Bryngelson**, A. Charalampopoulos, T. P. Sapsis, T. Colonius, "Neural-network-augmented Gaussian moment method for the statistics of cavitating bubble populations," *Bulletin of the American Physical Society* (2019)
4. T. Trummler, K. Schmidmayer, **S. H. Bryngelson**, T. Colonius, "Simulations of a collapsing gas bubble above a crevice," *SoCal Fluids XIII* (2019)
5. **S. H. Bryngelson**, T. Colonius, "Simulations and acoustics of humpback whale bubble-net feeding," *SoCal Fluids XIII* (2019)
6. **S. H. Bryngelson**, T. Colonius, "Modeling approaches for bubbly, cavitating flows," *Bulletin of the American Physical Society* (2018)
7. **S. H. Bryngelson**, J. B. Freund, "Floquet stability of tank-treading and tumbling capsules in viscous shear flow," *Bulletin of the American Physical Society* (2017)
8. **S. H. Bryngelson**, J. B. Freund, "Stability of flowing red blood cell trains," *Blood Flow,* Paris, France (2017)
9. **S. H. Bryngelson**, J. B. Freund, "Global stability of fully coupled capsule flow systems," *SIAM Computational Science and Engineering* (2017)
10. **S. H. Bryngelson**, J. B. Freund, "Stability and transition to chaos of regular capsule trains," *Bulletin of the American Physical Society* (2016)
11. **S. H. Bryngelson**, J. B. Freund, "Buckling and its effect on the confined flow of a capsule suspension," *Bulletin of the American Physical Society* (2015)

—— INVITED TALKS ——

1. University of Washington, Mechanical Engineering Seminar Series (2019)
2. University of Michigan–Ann Arbor, Mechanical Engineering Seminar Series (2019)
3. Massachusetts Institute of Technology, Mechanical Engineering (2019)
4. University of Vermont, Mechanical Engineering Seminar Series (2019)
5. University of Utah, Mechanical Engineering Seminar Series (2019)
6. University of Michigan–Dearborn, Mechanical Engineering Seminar Series (2019)

7. California Institute of Technology, Fluid Mechanics Research Conference (2018)
8. California Institute of Technology, Computational Flow Physics Group (2018)
9. ETH Zürich, Computational Science & Engineering Lab (2017)
10. University of Illinois at Urbana–Champaign, Fluid Mechanics Seminar (2017)
11. University of Illinois at Urbana–Champaign, Biology Interest Group (2015)

Awards

- Stanley Weiss Outstanding Dissertation Award — University of Illinois (2017)
- Hassan Aref Memorial Award for Research in Fluid Mechanics — University of Illinois (2016)
- Alumni Teaching Fellowship — University of Illinois (2015)
- Dean's List — University of Michigan (2010–2013)
- Pi Tau Sigma—Mechanical Engineering Honor Society, Member

Grants

—— FUNDED GRANTS ——

- Co-PI: XSEDE Allocation CTS120005, 9M CPU Hours ($135K dollar valuation)

—— PROJECTS SUPPORTED ——

- ONR MURI N0014-17-1-2676 (with Tim Colonius)
- ONR BRC N0014-17-1-2625 (with Tim Colonius)
- NIH 2P01-DK04881 (with Tim Colonius)
- DOE PSAAP II DE-NA0002374 (with Jonathan Freund, Carlos Pantano, Daniel Bodony)
- NSF CBET 13-36972 (with Jonathan Freund)

Software developed

I have developed several extreme-scale computational physics tools. A partial list is included below.

`MFC`: Multi-Component Flow Code
with V. Coralic, J. Meng, T. Colonius — `mfc-caltech.github.io`

- Multi-scale and multi-phase flow solver
- Multi-physics support
- Material interface sharpening
- MPI support, parallel I/O—preserves strong scaling
- High-order reconstruction and interface capturing
- Characteristic-based boundary conditions

`ECOGEN`: Evolutive, Compressible, Open-Source, Genuine, Easy, N-phase Flow Solver
with K. Schmidmayer, M. Rodriguez, E. Daniel, F. Petitpas — `code-mphi.github.io/ECOGEN`

- Multi-physics compressible flow solver
- Supports unstructured meshes
- Non-oscillatory diffuse interface method
- Adaptive mesh refinement with load balancing

`PlascomCM` and `Plascom2`: Multi-Physics Turbulent Flows
with E. Cisneros, M. Campbell, D. Buchta, J. B. Freund — `xpacc-dev.bitbucket.io/PlasCom2`

- Parallel Navier–Stokes solver
- Supports fluid-structure interaction
- Strong-shock capturing
- Large-eddy turbulence models
- Support for chemical reactions via Cantera
- Unstructured grids

`RBC3D`: Spectral Boundary Integral Flow Solver
with H. Zhao, J. Freund `available upon request`

- Solver for flexible objects and surfaces
- Spectral accuracy (spherical harmonics)
- Boundary conditions imposed via weak formulation
- Constitutive laws for capsules, cells, and droplets

`IMR`: Inertial Microcavitation Rheometry
with J. Spratt, J. Yang, C. Franck `available upon request`

- Computes the high strain-rate viscoelastic properties of soft materials
- Correlates bubble pressure and stress field to material kinematics with modular constitutive law
- Image processing available for analyzing experimental images