

Marc T. Henry de Frahan

US citizen, Applied Mathematics/Mechanical engineer

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Work Experience

Computational Scientist, National Renewable Energy Laboratory 2019-present
Turbulence and machine learning for wind turbines and combustion

Post-doctoral Researcher, National Renewable Energy Laboratory 2016-2019
Next-generation simulations of wind farms and combustion processes

Education

Deep Learning Specialization 2017-2018
Coursera
Topics: neural networks (CNN, RNN), deep learning frameworks (Keras, Tensorflow)

Ph.D. in Mechanical Engineering 2011-2016
University of Michigan, Ann Arbor, MI
Thesis: *Numerical simulations of shock and rarefaction waves interacting with interfaces in compressible multiphase flows*
Advisor: E. Johnsen, Assistant Professor of Mechanical Engineering

M.S. in Applied Mathematics Engineering 2009-2011
Université Catholique de Louvain, Belgium
Thesis: *Implementation of a Discontinuous Galerkin Method for hyperbolic PDEs on GPUs*
Advisors: Prof. J-F Remacle, Prof. P. Chatelain, Prof. V. Legat.

B.S. in Applied Mathematics Engineering 2007-2009
Université Catholique de Louvain, Belgium

Research Interests

Fluid mechanics - multiphase flows, hydrodynamic instabilities, turbulence
Energy - turbomachinery, combustion, wind farms
High order numerical methods for computational fluid dynamics
High performance computing with graphics processing units
Machine learning for improved physics models

Research Experience

Argonne Training Program on Extreme-Scale Computing, Argonne National Laboratory Summer 2017
Invited to an intensive 2-week workshop on high performance computing

NextProf Engineering Future Faculty Workshop, University of Michigan Fall 2015
Invited to participate in a workshop to prepare for faculty positions

International High Performance Computing Summer School, Hungary Invited to attend NSF workshop to learn new paradigms in scientific computing	Summer 2014
Lawrence Livermore National Laboratory, Livermore, CA Student intern Comparing Beryllium strength models with experimental data Supervisors: Dr. B. Remington and Dr. R. Cavallo	Summer 2012
Computational Methods in High Energy Density Plasmas, UCLA, CA Invited to attend a 6 week long workshop by the Institute for Pure and Applied Mathematics at the University of California - Los Angeles	Spring 2012
Lawrence Livermore National Laboratory, Livermore, CA Student intern Studied hydrodynamic instabilities in inertial confinement fusion targets Characterized growth factors during capsule compression Supervisors: Dr. L. J. Suter and Dr. D. S. Clark	Summer 2010
Lawrence Livermore National Laboratory, Livermore, CA Student intern Studied hot electron signatures and capsule preheat in the context of inertial confinement fusion as developed at the National Ignition Facility Supervisors: Dr. L. J. Suter and Dr. C. A. Thomas	Summer 2009
Lawrence Livermore National Laboratory, Livermore, CA Student intern Studied and optimized National Ignition Facility inertial confinement fusion target geometries using view factor calculations Supervisors: Dr. L. J. Suter and Dr. C. A. Thomas	Summer 2008

Leadership Experience

NREL Postdoctoral Committee Organizing networking and professional development activities	2016-2018
Sweetland Center for Writing, University of Michigan Dissertation Writing Group Leader Lead a group of PhD students in weekly dissertation writing and feedback sessions	Spring 2016
Mechanical Engineering Graduate Council, University of Michigan - STEM Communication Chair Communicate graduate student research to lay audiences - President Promote social, academic and professional development for ME graduate students - Graduate Seminar Chair Organize monthly seminars to showcase graduate student research	2013-2016
Graduate Student Advisory Committee, University of Michigan Representative for Department of Mechanical Engineering Identify and plan activities to promote community among engineering graduate students	2014-2015

Mentorship and Teaching Experience

Julia Ream, National Renewable Energy Laboratory	2019
Mentored Ph.D. graduate student for a project on turbulent supercritical CO ₂ jet simulations	
Prakash Mohan, National Renewable Energy Laboratory	2018
Mentored Ph.D. graduate student for a project on deep learning for LES models	
Jalil Alidoost, University of Michigan	2015-2016
Mentored senior undergraduate for a project on diffusive and kinetic properties of chair motion in the Shapiro Library	
Colby Hanley, University of Michigan	2015-2016
Mentored freshman undergraduate for a project on multi-GPU profiling for high-performance computing	
Graduate Student Instructor for ME 523: Computational Fluid Dynamics	Fall 2013
University of Michigan, Ann Arbor, MI	

Fellowships and Awards

Better Scientific Software Fellowship (honorable mention)	2018
Better Scientific Software (Department of Energy organization)	
AIAA CFD Best Student Paper Award (3^d place)	2015
American Institute of Aeronautics and Astronautics	
Rackham Predoctoral Fellowship	2015
University of Michigan	
Rackham Centennial Fellowship	2013
University of Michigan	
NIF Poster Winner	2012
Lawrence Livermore National Laboratory 2012 Summer Poster Session	
High Distinction	2011
M.S. in Applied Mathematics Engineering at the Université Catholique de Louvain	

Volunteer Service and Outreach

DAPCEP Instructor	Spring 2015
Organized and taught a 6-week long engineering discovery course for Detroit-area middle school students	
Volunteer Instructor, Adams Academy Engineering Club	2014-2016
Instructed fun basic science and engineering projects at a local primary school	
Graduate Student Recruiter, University of Michigan	2012-2016
Organized and participated in recruitment events graduate students visiting the Mechanical Engineering department	

Selected Publications

M. T. Henry de Frahan, S. Yellapantula, R. King, M. S. Day, and R. W. Grout, **Deep learning**

for presumed probability density function models, *Comb. and Flame*, 208:436–450, 2019, Pages 436–450

P. Mohan, M. T. Henry de Frahan, R. King, and R. Grout, **A block-random algorithm for learning on distributed, heterogeneous data**, *arXiv:1903.00091*, 2019

M. T. Henry de Frahan, and R. Grout, **Data recovery in computational fluid dynamics through deep image priors**, *arXiv:1901.11113*, 2019

M. T. Henry de Frahan, J. L. Belof, R. M. Cavallo, V. A. Raevsky, O. N. Ignatova, A. Lebedev, D. S. Ancheta, B. S. El-dasher, J. N. Florando, G. F. Gallegos, E. Johnsen, and M. M. LeBlanc, **Experimental and Numerical Investigations of Beryllium Strength Models Using the Rayleigh-Taylor Instability**, *featured article in J. Appl. Phys.*, 117(22):225901, 2015

M. T. Henry de Frahan, S. Varadan, and E. Johnsen, **A new limiting procedure for discontinuous Galerkin methods applied to compressible multiphase flows with shocks and interfaces**, *J. Comput. Phys.*, 280(0):489 – 509, 2015

M. T. Henry de Frahan, P. Movahed, and E. Johnsen, **Numerical simulations of a shock interacting with successive interfaces using the Discontinuous Galerkin method: the multilayered Richtmyer-Meshkov and Rayleigh-Taylor instabilities**, *Shock Waves*, 25(4):329–345, 2015

C. A. Di Stefano, G. Malamud, M. T. Henry de Frahan, C. C. Kuranz, A. Shimony, S. R. Klein, R. P. Drake, E. Johnsen, D. Shvarts, V. A. Smalyuk, and D. Martinez, **Observation and modeling of mixing-layer development in high-energy-density, blast-wave-driven shear flow**, *Phys. Plasmas*, 21(5):056306, 2014

Conference Proceedings

S. Yellapantula, B. A. Perry, M. T. Henry de Frahan, M. E. Mueller, and R. W. Grout, **Machine Learning based models for joint PDF shapes for multi-scalar mixing in turbulent flows**, 11th *U.S. National Combustion Meeting*, 2019

M. T. Henry de Frahan, L. Khieu, and E. Johnsen, **High-order Discontinuous Galerkin Methods Applied to Multiphase Flows**, 22^d *AIAA Computational Fluid Dynamics Conference. American Institute of Aeronautics and Astronautics*, doi: 10.2514/6.2015-3045, 2015, AIAA CFD Best Student Paper Award (3^d place)

M. T. Henry de Frahan and E. Johnsen, **Discontinuous Galerkin method for multifluid Euler equations**, *In 21st AIAA Computational Fluid Dynamics Conference. American Institute of Aeronautics and Astronautics*, doi: 10.2514/6.2013-2595, 2013

M. T. Henry de Frahan, P. Movahed, and E. Johnsen, **Investigating the multilayered Richtmyer-Meshkov instability with high-order accurate numerical methods**, *In 29th International Symposium on Shock Waves 2, Springer International Publishing*, 2015

Conference Presentations

M. T. Henry de Frahan, R. King, R. Grout, **Data recovery for computational fluid dynamics using deep image priors**, *SIAM CSE*, Feb. 2019, Spokane, WA

- M. T. Henry de Frahan, S. Yellapantula, R. King, M. Day, R. Grout, **A-priori analysis of joint PDF of mixture fraction and progress variable trained using machine learning techniques**, *APS 71st Meeting of the Division of Fluid Dynamics*, Nov. 2018, Atlanta, GA
- S. Yellapantula, M. T. Henry de Frahan, R. King, M. Day, R. Grout, **A-priori analysis of a data driven closure model trained from a reacting DNS of a Low-Swirl Burner**, *APS 71st Meeting of the Division of Fluid Dynamics*, Nov. 2018, Atlanta, GA
- M. T. Henry de Frahan, S. Yellapantula, G. Vijayakumar, R. Knaus, M. Sprague, **Hybrid RANS-LES using high-order numerical methods**, *APS 70th Meeting of the Division of Fluid Dynamics*, Nov. 2017, Denver, CO
- M. T. Henry de Frahan, M. S. Day, J. B. Bell, R. W. Grout, **Filtering in large eddy simulations with adaptive mesh refinement**, *29th Parallel CFD Conference*, May 2017, Glasgow, Scotland
- M. T. Henry de Frahan, E. Johnsen, **Circulation in blast driven instabilities**, *APS 69th Meeting of the Division of Fluid Dynamics*, Nov. 2016, Portland, OR
- M. T. Henry de Frahan, S. Beig, B. Aboulhasanzadeh, H. Ganesh, S. L. Ceccio, and E. Johnsen, **A new mixture model for compressible multiphase flows**, *9th International Conference on Multiphase Flow*, May 2016, Firenze, Italy
- M. T. Henry de Frahan, H. Ganesh, S. L. Ceccio, and E. Johnsen, **Numerical simulations of high-void-fraction bubbly flow over a wedge**, *9th International Symposium on Cavitation*, Dec. 2015, Lausanne, Switzerland
- M. T. Henry de Frahan, E. Johnsen, **Interactions of Blast Waves with Perturbed Interfaces**, *APS 68th Meeting of the Division of Fluid Dynamics*, Nov. 2015, Boston, MA
- M. T. Henry de Frahan, L. Khieu, and E. Johnsen, **High-order Discontinuous Galerkin Methods Applied to Multiphase Flows**, *23^d AIAA Computational Fluid Dynamics Conference*, Jun. 2015, Dallas, Tx
- M. T. Henry de Frahan, E. Johnsen, **Numerical simulations of hydrodynamic instabilities with GPUs**, *IPAM Computational Methods in High Energy Density Plasmas Reunion Conference*, Dec. 2014, Lake Arrowhead, CA
- M. T. Henry de Frahan, E. Johnsen, **Hydrodynamic instabilities in blast-driven systems**, *APS 67th Meeting of the Division of Fluid Dynamics*, Nov. 2014, San Francisco, CA
- M. T. Henry de Frahan, R. P. Drake, E. Johnsen, **Hydrodynamic instabilities of finite width layers**, *APS 56th Meeting of the Division of Plasma Physics*, Oct. 2014, New Orleans, LA
- E. Johnsen, M. T. Henry de Frahan, S. A. Beig, **Numerical simulations of gas-liquid interfaces in compressible flows**, *AIAA Aviation Forum*, Jun. 2014, Atlanta, GA
- M. T. Henry de Frahan, E. Johnsen, **Blast-driven hydrodynamic instability**, *APS 66th Meeting of the Division of Fluid Dynamics*, Nov. 2013, Pittsburgh, PA
- M. T. Henry de Frahan, J. L. Belof, R. M. Cavallo, O. Ignatova, E. Johnsen, B. A. Remington, V. Raevsky, **Analysis of recent Beryllium Rayleigh-Taylor experiments**, *Fundamentals of Pu Work-*

shop XIII, Sep. 2013, Sarov, Russia

M. T. Henry de Frahan, P. Movahed, E. Johnsen, **Investigating the multi-layered Richtmyer-Meshkov instability with high-order accurate numerical methods**, 29th *International Symposium on Shock Waves*, Jul. 2013, Madison, WI

M. T. Henry de Frahan, E. Johnsen, **Discontinuous Galerkin method for multifluid Euler equations**, 21st *AIAA Computational Fluid Dynamics Conference*, Jun. 2013, San Diego, CA

M. T. Henry de Frahan, J. L. Belof, R. M. Cavallo, O. Ignatova, E. Johnsen, B. A. Remington, V. Raevsky, **Beryllium strength under extreme dynamic loading conditions**, *APS 54th Meeting of the Division of Plasma Physics*, Oct. 2012, Providence, RI

Skills

Scientific programming

C/C++, Python, Git, Bash, R, C for CUDA, MPI, OpenMP, L^AT_EX, VisIt, Gmsh, Matlab

Operating systems

GNU/Linux, OSX, Windows

Languages

English, French

Memberships

American Physical Society	2012-2018
American Institute of Aeronautics and Astronautics	2012-2017