Marc T. Henry de Frahan

US citizen, Applied Mathematics/Mechanical engineer

marchdf@gmail.com
github.com/marchdf

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

Publications

H. Sitaraman, S. Yellapantula, M. T Henry de Frahan, B. Perry, J. Rood, R. W. Grout, M. S. Day, **Adaptive mesh based combustion simulations of direct fuel injection effects in a supersonic cavity flame-holder**, *Comb. and Flame*, 232, 2021

M. T Henry de Frahan, N. T Wimer, S. Yellapantula, R. W. Grout, **Deep reinforcement learning for dynamic control of fuel injection timing in multi-pulse compression ignition engines**, *Int. J. Eng. Res.*, 2021

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

combustion LES models from reacting direct numerical simulation, *Data Analysis for Direct Num. Sim. of Turb. Comb.*, 2020, Pages 273-292

M. T. Henry de Frahana, 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**, 11^{th} *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* 71^{st} *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* 71^{st} *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* 70^{th} *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**, 29^{th} *Parallel CFD Conference*, May 2017, Glasgow, Scotland

M. T. Henry de Frahan, E. Johnsen, **Circulation in blast driven instabilities**, *APS* 69^{th} *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**, 9^{th} *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**, 9^{th} *International Symposium on Cavitation*, Dec. 2015, Lausanne, Switzerland

M. T. Henry de Frahan, E. Johnsen, **Interactions of Blast Waves with Perturbed Interfaces**, *APS* 68^{th} *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* 67^{th} *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* 56^{th} *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* 66^{th} *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 Workshop 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**, 29^{th} *International Symposium on Shock Waves*, Jul. 2013, Madison, WI

M. T. Henry de Frahan, E. Johnsen, **Discontinuous Galerkin method for multifluid Euler equations**, 21^{st} *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* 54^{th} *Meeting of the Division of Plasma Physics*, Oct. 2012, Providence, RI

Mentorship and Teaching Experience

Nick Wimer, National Renewable Energy Laboratory 2019-2021
Postdoctoral research mentor

Bruce Perry, National Renewable Energy Laboratory 2019-2021
Postdoctoral research mentor

Likhit Ganedi, Carnegie-Mellon Univeristy 2021
Mentor for summer internship on hybrid particle-continuum solvers

Jani Adcock, Stanford University 2020-2021
CSGF practicum mentor

Julia Ream, Florida State University 2019-2021
Co-advisor of Ph.D. committee for work on turbulent supercritical CO2 jet simulations

Prakash Mohan, University of Texas-Austin 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

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 Summer 2014
Invited to attend NSF workshop to learn new paradigms in scientific computing

Lawrence Livermore National Laboratory, Livermore, CA Summer 2012
Student intern
Comparing Beryllium strength models with experimental data
Supervisors: Dr. B. Remington and Dr. R. Cavallo

Computational Methods in High Energy Density Plasmas, UCLA, CA Spring 2012
Invited to attend a 6 week long workshop by the Institute for Pure and Applied Mathematics at the University of California - Los Angeles

Lawrence Livermore National Laboratory, Livermore, CA Summer 2010
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

Lawrence Livermore National Laboratory, Livermore, CA Summer 2009
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

Lawrence Livermore National Laboratory, Livermore, CA Summer 2008
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

Leadership Experience

NREL Postdoctoral Committee 2016-2018
Organizing networking and professional development activities

Sweetland Center for Writing, University of Michigan Spring 2016
Dissertation Writing Group Leader
Lead a group of PhD students in weekly dissertation writing and feedback sessions

Mechanical Engineering Graduate Council, University of Michigan 2013-2016
- 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

Graduate Student Advisory Committee, University of Michigan 2014-2015
Representative for Department of Mechanical Engineering
Identify and plan activities to promote community among engineering graduate students

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

Skills

Scientific programming
C/C++, Python, Git, Bash, R, C for CUDA, MPI, OpenMP, LaTeX, 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