

# LOIC CAPPANERA

Department of Mathematics  
University of Houston  
Houston, TX 77004

Email: lmcappan@central.uh.edu  
Office: PGH 602  
<https://www.math.uh.edu/~lcappan/>

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## EMPLOYMENT & EDUCATION

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Assistant Professor, University of Houston, TX	2019 - Present
Postdoctoral Research Associate, Rice University, Houston, TX	2017 - 2019
Postdoctoral Research Associate, Texas A&M University, College Station, TX	2016 - 2016
Ph.D. Fluid Mechanics, Paris-Saclay University, Orsay, France	2012 - 2015
M.S. Mathematics, Paris-Sud University, Orsay, France	2008 - 2012
French Agregation in Mathematics, ENS Cachan, Cachan, France	2010 - 2011
B.S. Mathematics, Paris-Sud University, Orsay, France	2005 - 2008

## GRANTS

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NSF DMS- <a href="#">2430460</a> (\$42,244)	2025 - 2026
PI: Yunhui He.	
Co-PIs: Loic Cappanera, Andreas Mang, Min Wang.	
<i>CBMS Conference: Research at the Interface of Applied Mathematics and Machine Learning.</i>	
NSF DMS- <a href="#">2208046</a> (\$170,913)	2022 - 2025
PI: Loic Cappanera.	
<i>Numerical methods for incompressible multiphase flows applied to magnetohydrodynamics.</i>	
Invited Professor (Missionnaires Invités) at Paris-Saclay University (\$3,654)	June 2023
<i>Collaborative research on magnetohydrodynamics instabilities in liquid metal batteries.</i>	

## RESEARCH INTERESTS

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Finite Element Methods. Incompressible Navier-Stokes equations. Maxwell equations. Level Set Methods. Flows in porous media. Integro-Differential Equations. Applications to Turbulence, Thermal Convection, and Magnetohydrodynamics.

## BIBLIOGRAPHIC AND SOFTWARE DATABASE

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### Bibliographic databases.

- [Google Scholar Profile](#)

- ResearchGate Profile
- ORCID: 0000-0002-3871-1073

## Open source MHD-code SFEMaNS.

- <https://github.com/jean-luc-guermond/SFEMaNS>

## PUBLICATIONS

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24. S. Benard, W. Herreman, L. Cappanera, C. Nore "Connecting alloy composition to electrical potential in liquid metal batteries", submitted
23. D. Geneste, H. Faller, T. Chaabo, A. Cheminet, V. Valori, Y. Ostovan, L. Cappanera, C. Cuvier , F. Daviaud, J.-M. Foucaut, J.-L. Guermond, J.-P. Laval, C. Nore, V. Padilla, C. Wiertel-Gasquet, B. Dubrulle, "Experimental study of subgrid stresses at the Kolmogorov scale in a turbulent von Kármán flow", submitted
22. A. Vu, L. Cappanera, *Error Analysis of a Semi-Implicit Time-Stepping Scheme for Incompressible Flows with Variable Density and Viscosity*, Journal of Numerical Mathematics (2024), DOI: 0.1515/jnma-2024-0033
21. G. Jaramillo, L. Cappanera, C. Ward, *Analysis and Simulation of a Nonlocal Gray-Scott model*, SIAM Journal on Applied Mathematics 84 (3), 856-889, DOI: 10.1137/22M1542441
20. S. Bénard, L. Cappanera, W. Herreman, C. Nore, *Magnetic field based finite element method for magneto-static problems with discontinuous electric potential distributions*, Comptes Rendus. Mécanique, 351.S1 (2023): 1-20, DOI: 10.5802/crmeca.184
19. W. Herreman, L. Wierzchalek, G. M. Horstmann, L. Cappanera and C.Nore, *Stability theory for metal pad roll in cylindrical liquid metal batteries*, Journal of Fluid Mechanics, 962 (2023): A6, DOI: <https://doi.org/10.1017/jfm.2023.238>
18. G. Sosa Jones, B. Riviere, L. Cappanera, *Existence and convergence of a discontinuous Galerkin method for the compressible three-phase flow problem in porous media*, IMA Journal of Numerical Analysis (2022) 00, 1–34 , DOI: <https://doi.org/10.1093/imanum/dr ac053>
17. V. Girault, B. Riviere, L. Cappanera, *A Finite element method for degenerate two-phase flow in porous media. Part II: convergence*, Journal of Numerical Mathematics, 29 (2021). DOI: 10.1515/jnma-2020-0005
16. G. Jaramillo, L. Cappanera, C. Ward, *Numerical Methods for a Diffusive Class Nonlocal Operators*, J Sci Comput, 88, 30 (2021), DOI: <https://doi.org/10.1007/s10915-021-01543-7>
15. W. Herreman, C. Nore, L. Cappanera, J.-L. Guermond, *Efficient mixing by swirling electrovortex flows in liquid metal batteries*, Journal of Fluid Mechanics, 915 (2021) A17, DOI: <https://doi.org/10.1017/jfm.2021.79>
14. H. Faller, D. Geneste, T. Chaabo, A. Cheminet, V. Valori, Y. Ostovan, L. Cappanera, Ch. Cuvier, F. Daviaud, J.-M. Foucaut, J.-L. Guermond, J.-Ph. Laval, C. Nore, V. Padilla, C. Wiertel-Gasquet and B. Dubrulle, *On the nature of intermittency in a turbulent von Karman flow*, Journal of Fluid Mechanics, 914 (2021) A2, DOI: <https://doi.org/10.1017/jfm.2020.908>

13. C. Nore, L. Cappanera, J.-L. Guermond, T. Weier, W. Herreman, *Feasibility of metal pad roll instability experiments at room temperature*, Phys. Rev. Lett., 126 (2021), 184501, DOI: <https://doi.org/10.1103/PhysRevLett.126.184501>
12. V. Girault, B. Riviere, L. Cappanera, *A Finite element method for degenerate two-phase flow in porous media. Part I: well-posedness*, Journal of Numerical Mathematics, 29 (2021). DOI: 10.1515/jnma-2020-0004
11. L. Cappanera, P. Debue, H. Faller, D. Kuzzay, E-W. Saw, C. Nore, J.-L. Guermond, F. Daviaud, C. Wiertel-Gasquet, B. Dubrulle, *Turbulence in realistic geometries with moving boundaries: when simulations meet experiments*, Computer & Fluids, 214 (2021): 104750, DOI: 10.1016/j.compfluid.2020.104750
10. W. Herreman, S. Benard, C. Nore, P. Personnettaz, L. Cappanera, J.-L. Guermond, *Solutal buoyancy and electrovortex flow in liquid metal batteries*, Physical Review Fluids, 5 (2020), DOI: 10.1103/PhysRevFluids.5.074501
9. W. Herreman, C. Nore, J.-L. Guermond, L. Cappanera, N. Weber, G. M. Horstmann, *Metal pad roll instability in cylindrical reduction cells*, Journal of Fluid Mechanics, 878 (2019) 598-646, DOI: 10.1017/jfm.2019.642
8. W. Herreman, C. Nore, P. Ziebell Ramos, L. Cappanera, J.-L. Guermond, *Numerical simulation of electro-vortex flows in cylindrical fluid layers and liquid metal batteries*, Physical Review Fluids, 4 (2019), DOI: 10.1103/PhysRevFluids.4.113702
7. L. Cappanera and B. Riviere, *Discontinuous Galerkin method for solving the black oil problem in porous media*, Numer Methods Partial Differential Eq. (2018) 1-29, DOI: 10.1002/num.22324
6. C. Nore, D. Castanon Quiroz, L. Cappanera and J.-L. Guermond, *Numerical simulation of the Von-Karman-Sodium experiment*, Journal of Fluid Mechanics, 854, (2018) 164-195, DOI: 10.1017/jfm.2018.582
5. L. Cappanera, J.-L. Guermond, W. Herreman, C. Nore, *Momentum based approximation of incompressible multiphase fluid flows*, Int. J. Numer. Meth. Fluids, 86 (2018) 541–563, DOI: 10.1002/fld.4467
4. R. Zanella, C. Nore, F. Bouillault, L. Cappanera, I. Tomas, X. Mininger and J.-L. Guermond, *Study of Magnetoconvection Impact on a Coil Cooling by Ferrofluid with a Spectral / Finite Element Method*, IEEE Transactions on Magnetics, 54:3 (2018) 460014, DOI: 10.1109/TMAG.2017.2749539
3. C. Nore, D. Castanon Quiroz, L. Cappanera and J.-L. Guermond, *Direct numerical simulation of the axial dipolar dynamo in the Von-Karman-Sodium experiment*, Euro. Phys. Letters, 114 (2016) 65002, DOI: 10.1209/0295-5075/114/65002
2. L. Cappanera, J.-L. Guermond, J. Léorat , C. Nore, *Two spinning ways for precession dynamo*, Physical Review E, 93 (2016) 043113, L. Cappanera, J.-L. Guermond, J. Léorat, C. Nore, "Two spinning ways for precession dynamo", Physical Review E, 93 (2016) 043113, DOI: 10.1103/physreve.93.043113
1. W. Herreman, C. Nore, L. Cappanera, J.-L. Guermond, *Taylor instability in liquid metal columns and liquid metal batteries*, Journal of Fluid Mechanics, 771 (2015) 79-114, DOI: 10.1017/jfm.2015.159

## INVITED TALKS

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- 2024** *Partial Differential Equations with nonlocal diffusive operators: modeling and approximation.* Continuum Mechanics Seminar, University of Nebraska-Lincoln, Lincoln, NE (online, 11/17/2024).
- 2024** *Partial Differential Equations with nonlocal diffusive operators: modeling and approximation.* NASC seminar, Rice University, Houston, TX (09/24/2024).
- 2023** *Efficient and robust pseudo-spectral methods for incompressible flows with variable density.* Computational and Applied Mathematics Seminar, University of Tennessee, Knoxville, TN (10/17/2023).
- 2023** *Numerical methods for incompressible Navier-Stokes equations with variable density.* CMAI Colloquium, George Mason University, Fairfax, VA (10/06/2023).
- 2023** *Projection and artificial compressibility methods for incompressible flows with variable density.* Numerical analysis and PDEs seminar, Math. Dept. University Paris-Saclay, Orsay, France (06/08/2023).
- 2023** *Efficient numerical methods for incompressible multiphase flows and applications to magnetohydrodynamics.* Scientific Computing Seminar, Math. Dpt. University of Houston, Houston, TX (04/06/2023).
- 2023** *Pseudo-spectral methods for incompressible flows with variable density.* Applied Mathematics Seminar, Math. Dpt. Texas Tech University (online, 03/28/2023).
- 2023** *Robust and efficient numerical methods for incompressible flows with variable density.* Colloquium, Math. Dept Oakland University, Rochester, MI (03/14/2023).
- 2022** *Robust numerical methods for incompressible flows with variable density.* Numerical Analysis seminar, Math. Dept. TAMU, College Station, TX (09/28/2022).
- 2018** *Nonlinear stabilization of the magnetohydrodynamics equations. Applications to multiphase flow.* Scientific Computing Seminar, University of Houston, Houston, TX (10/04/2018).
- 2017** *Nonlinear stabilization of magnetohydrodynamics equations. Applications to multiphase flow.* CAAM Colloquium, Rice University, Houston, TX (11/09/2017).

## CONTRIBUTED TALKS

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- 2024** *Numerical methods for immiscible incompressible multiphase flows with thermal convection.* WCCM-PANACM, Vancouver, Canada (07/21-26/2024).
- 2024** *Analysis and numerical simulations of a nonlocal Gray-Scott model.* Finite Element Rodeo, Rice University, Houston (03/08-09/2024).
- 2023** *Pseudo-spectral methods for incompressible two-phase flows with temperature and magnetic effects.* AMS Fall Eastern Sectional Meeting, Buffalo, NY (09/09-10/2023).
- 2023** *Discontinuous Galerkin method for three-phase flows in porous media.* USNCCM 17, Albuquerque, NM (07/23-27/2023).
- 2023** *Numerical methods for incompressible flows with variable density and applications to liquid metal batteries.* Math 2 Producut (M2P) conference, Taormina, Sicily, Italy (05/30-06/01/2023).

- 2023** *Numerical methods for multiphase flows with discontinuous electric potential distributions.* AMS Spring Central Meeting Section, Cincinnati, OH (04/15-16/2023).
- 2023** *Finite element methods for magneto-static problems with discontinuous electric potential distribution.* Finite element Rodeo, TAMU, College Station, TX (03/24/25/2023).
- 2023** (canceled due to visa issue) *Robust numerical methods for the incompressible Navier-Stokes equations with variable density.* SIAM CSE, Amsterdam, Netherlands (02/26/2023-03/03/2023)
- 2022** *Pseudo-spectral methods for the incompressible magnetohydrodynamics equations with variable density.* 5th SIAM TX-LA Annual Meeting, Houston, TX (11/04-06/2022).
- 2022** *Artificial compressibility and splitting methods for the incompressible Navier-Stokes equations with variable density.* AMS Fall Central Meeting Section, El Paso, TX (09/17/2022).
- 2022** *Artificial compressibility and projection methods for incompressible multiphase flows.* 6th Coastal Bend Mathematics & Statistics Conference CBMSC (online, 04/09/2022).
- 2022** *Projection and artificial compression methods for incompressible multiphase flows.* Finite Element Rodeo, Southern Methodist University, Dallas, TX (03/04-05/2022).
- 2021** *Projection and artificial compression methods for incompressible multiphase flows.* 4th SIAM TX-LA Annual Meeting, UTRGV, South Padre Island, TX (11/05-07/2021).
- 2021** *Discontinuous Galerkin method for black oil problem: convergence and applications.* SIAM SEAS 2021, Auburn University, Auburn, AL (online, 09/18-19/2021).
- 2021** *Discontinuous Galerkin discretization of the three-component three-phase flow problem.* WCCM-ECCOMAS Congress (online, 01/11-15/2021).
- 2020** *Momentum based approximation of incompressible flows with variable density and viscosity.* 3rd SIAM TX-LA Annual Meeting (online, 10/18/2020).
- 2020** *Momentum based approximation of incompressible flows with variable density and viscosity. Application to magnetohydrodynamics.* AMS Fall Central Meeting (online, 09/12/2020).
- 2020** (symposium/talk canceled due to pandemic) *Momentum based approximation of multiphase flows and magnetohydrodynamics problems.* SIAM Annual Meeting.
- 2019** *Flexible Discretizations of the Three-component Three-phase Flow Problem.* SPE Reservoir Simulation Conference Galveston, TX (04/10/2019).
- 2019** *Discontinuous Galerkin method for solving the black oil problem in porous media.* SIAM Conference on Mathematical & Computational Issues in the Geosciences (GS19), Houston, TX (03/14/2019).
- 2018** *Discontinuous Galerkin method for solving the black oil problem in porous media.* Finite Element Circus, University of Delaware, Newark, DE (11/09-10/2018).
- 2018** *Approximation of porous media flow. Black Oil Model.* Finite Element Rodeo, Louisiana State University, Baton-Rouge, LA (02/23-24/2018).
- 2017** *Momentum based approximation of incompressible multiphase flows and applications to metal pad roll instability.* International Symposium on Bifurcations and Instabilities in Fluid Dynamics (BIFD), The Woodlands, TX (07/11-14/2017).
- 2016** *Momentum based approximation of incompressible multiphase flow.* Finite Element Rodeo, College Station, TX (03/04-05/2016).

- 2015** *Momentum based approximation of incompressible multiphase flows with SFEMaNS MHD-code.* Journée de Dynamique des Fluides du Plateau d'Orsay (JDFP), Orsay, France (03/24/2015).
- 2014** *Multiphase flow computations with SFEMaNS-MHD code.* Journée de Dynamique des Fluides du Plateau d'Orsay (JDFP), Orsay, France (02/11/2014).
- 2015** *Momentum based approximations of incompressible multiphase flows* Bifurcations and Instabilities in Fluid Dynamics (BIFD), Paris, France (07/15/2015).
- 2014** *Multiphase flow computations with SFEMaNS-MHD code.* European GDR Dynamo, Cambridge, England (09/01-04/2014).

## POSTER

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- 2015** *Momentum-based approximation of incompressible multiphase fluid flows.* Rencontre du Non Linéaire (RNL), Paris, France (03/2015).
- 2014** *Multiphase flow computations with SFEMaNS-MHD code.* Colloque Alain Bouyssy, Orsay, France (02/2014). Awarded with Best Poster.

## MENTORING

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### Postdoctoral Research Associate

- Giselle Sosa Jones (Fall 2020-Summer 2022)  
Topics: Discontinuous Galerkin finite element methods for multiphase flows in highly heterogeneous media.  
Current position: Assistant Professor, Department of Mathematics and Statistics, Oakland University, Rochester, MI.

### Graduate Students

- Salvatore Giordano (Fall 2023-present)  
Topics: Artificial compressibility techniques for incompressible Navier-Stokes equations with variable density.
- Mark Simmons (Fall 2023-present)  
Topics: High-order Discontinuous Galerkin finite element methods for flows in porous media with mass transfer effect.
- An Vu (Fall 2021-Summer 2024)  
Topics: Projection methods for incompressible Navier-Stokes equations with variable density and turbulent thermal convection.  
Current position: Assistant Professor, Department of Mathematics, University of St. Thomas, Houston, TX (starting date: Fall 2024).

### Master Students

- Taylor Ennadi (Fall 2024-Spring 2025).  
Topics: Finite Element Methods for incompressible multiphase flows and applications to turbulent thermal convection.

### **Undergraduate Students**

- Kaya Rende (Spring 2025)  
Topics: Introduction to Finite Element methods with applications to the approximation of the Navier-Stokes equations.
- Walker Bordovsky (Fall 2024)  
Topics: Introduction to Finite Element methods and applications to computational fluid dynamics.
- Quoc Nguyen (Summer 2022, ~4 weeks)  
Topics: Introduction to Finite Element methods and FreeFEM++ software.  
Current position: Graduate Student, Department of Mathematics, University of Houston.

### **TEACHING EXPERIENCE**

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#### **University of Houston**

MATH 6371: Numerical Analysis II	Sp-2024
MATH 2318: Linear Algebra	Sp-2024, Fa-2022
MATH 6370: Numerical Analysis I	Fa-2023
MATH 4364: Intro to Numerical Analysis in Scientific Computing	Sp-2023
MATH 3363: Intro to PDEs	Fa-2022, Sp-2022, Fa-2020
MATH 4335: Partial Diff Equations I	Fa-2021
MATH 4377-6308: Advanced Linear Algebra I	Sp-2021
MATH 1451: Accelerated Calculus II	Sp-2020
MATH 1450: Accelerated Calculus I	Fa-2019

#### **Rice University**

CAAM 519: Computational Science I	Fa-2018, Fa-2017
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#### **IUT Paris-Saclay University**

General Mathematics (Calculus, ODEs)	Sp-2015, Sp-2014, Fa-2012
Computer Science (Excel, PowerPoint, Statistics)	Sp-2015, Sp-2014, Fa-2012
Graph Theory	Sp-2014

### **SERVICE**

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#### **University of Houston Committees:**

- Scientific Computing Seminar Committee, Fall 2023 - present.
- Graduate Studies Committee, Fall 2022 - present.
- Colloquium Committee, Spring 2021 - present (Committee Chair starting Summer 2024).

- Numerical Analysis Hiring Committee (open rank), Fall 2023 - Spring 2024.

#### **PhD Thesis Committees:**

**2024** An Vu (adviser: Loïc Cappanera)

**2023** Manoj Subedi (adviser: Krešimir Josić)

**2022** Thuyen Dang (adviser: Yuliya Gorb)

#### **Organization of Conferences:**

**2022** Member of the local organizing committee (chair: William Ott) of the **5th SIAM TX-LA Annual Meeting**, Houston TX, 11/04-06/2022.

#### **Organization of Minisymposia & Workshops:**

**2024** Co-organizer (w/ Keegan Kirk and Giselle Sosa Jones) of WCCM minisymposium, *Recent Advances in discretization techniques for Coupled Problems in Incompressible Fluid Dynamics, WCCM-PANACM 2024*, Vancouver, Canada, 07/21-26/2024.

**2023** Co-organizer (w/ Tamas Horvath and Giselle Sosa Jones) of USNCCM minisymposium, *Recent Advances in FE Methods for Coupled Problems in Incompressible Fluid Dynamics, USNCCM 17*, Albuquerque NM, 07/23-27/2023.

**2023** Co-organizer (w/ Tamas Horvath) of SIAM minisymposium, *Robust finite element methods for convection-diffusion problems, SIAM CSE 23*, Amsterdam, Netherlands, 02/26-/2023 03/03/2023

**2022** Co-organizer (w/ Giselle Sosa Jones) of SIAM minisymposium, *Numerical methods and applications for geosciences, 5th SIAM TX-LA Annual Meeting*, Houston TX, 11/04-06/2022.

**2021** Organizer of SIAM minisymposium, *Numerical methods for multi-phase flows in porous media, 4th SIAM TX-LA Annual Meeting*, University of Texas Rio Grande Valley, South Padre Island, TX, 11/05-07/2021.

#### **Reviewer for Journals:**

- **AMS** - MathSciNet
- **CAMWA** - Computers & Mathematics with Applications
- **CMAM** - Computational Methods in Applied Mathematics
- **CMAME** - Computer Methods in Applied Mechanics and Engineering
- **JMAA** - Journal of Mathematical Analysis and Applications
- **JOMP** - Springer Journal of Scientific Computing
- **MCOM** - AMS Mathematics of Computation
- **NACO** - Numerical Algebra, Control and Optimization
- **NMPDE** - Numerical Methods for Partial Differential Equations
- **SISC** - SIAM Journal on Scientific Computing
- **Springer Nature** - Nature Physics