

Mohsen Sadr

MIT
Department of Mechanical Engineering
Cambridge, USA

Website: mohsensadr.github.io
GitHub: github.com/mohsensadr
Email: msadr@mit.edu
ORCID: 0000-0003-0241-8163

Scientific Appointments

- Jul. 2025 - present: Research Affiliate, MIT, Department of Mechanical Engineering, Cambridge, USA.
Collaborators: Prof. Nicolas Hadjiconstantinou and Prof. Kamal Youcef-Toumi
- Jul. 2023 - Jun. 2025: Postdoc/Scientist, ETH, Paul Scherrer Institute, Switzerland.
Collaborator: Dr. Andreas Adelmann
- Dec. 2021 - Jun. 2023: Postdoc Fellow, MIT, Department of Mechanical Engineering, Cambridge, USA.
Collaborators: Prof. Nicolas Hadjiconstantinou and Prof. Kamal Youcef-Toumi
- Oct. 2020 - Nov. 2021: Scientific Collaborator, EPFL, Swiss Plasma Center, Switzerland.
Collaborator: Prof. Laurent Villard

Education

- 2017 - 2020: Ph.D. (Dr. rer. nat.) in Applied Mathematics, RWTH Aachen University, Germany.
“*Efficient Monte Carlo description of multi-phase and multi-scale fluid flows in kinetic theory*”
Advisers: Prof. Manuel Torrilhon & Dr. M. Hossein Gorji
- 2014 - 2017: M.Sc. in Simulation Sciences, RWTH Aachen University, Germany.
“*On the Fokker-Planck description of dense flows*”
- 2009 - 2013: B.Sc. in Mechanical Engineering, KN Toosi University of Technology, Tehran, Iran.
“*Modeling losses of axial flow compressors by fundamental methods*”

Peer-reviewed Publications

1. **Mohsen Sadr**, Tony Tohme, and Kamal Youcef-Toumi. Data-driven discovery of PDEs via the adjoint method. *Transactions on Machine Learning Research*, 2025.
doi: openreview.net/forum?id=Az3mJ4d1eT
2. **Mohsen Sadr**, Nicolas G. Hadjiconstantinou, and M. Hossein Gorji. Wasserstein-penalized entropy closure: A use case for stochastic particle methods. *Journal of Computational Physics*, 511:113066, 2024.
doi: [10.1016/j.jcp.2024.113066](https://doi.org/10.1016/j.jcp.2024.113066)
3. Tony Tohme, **Mohsen Sadr**, Kamal Youcef-Toumi, and Nicolas G. Hadjiconstantinou. MESSY estimation: Maximum-entropy based stochastic and symbolic density estimation. *Transactions on Machine Learning Research*, 2024.
doi: openreview.net/forum?id=Y2ru0LuQeS
4. **Mohsen Sadr** and Nicolas G. Hadjiconstantinou. Variance reduced particle solution of the Fokker-Planck equation with application to rarefied gas and plasma dynamics. *Journal of Computational Physics*, 492:112402, 2023.
doi: [10.1016/j.jcp.2023.112402](https://doi.org/10.1016/j.jcp.2023.112402)

5. **Mohsen Sadr** and Nicolas G. Hadjiconstantinou. A variance-reduced direct Monte Carlo simulation method for solving the Boltzmann equation over a wide range of rarefaction. *Journal of Computational Physics*, 472:111677, 2023.
doi: [10.1016/j.jcp.2022.111677](https://doi.org/10.1016/j.jcp.2022.111677)
6. Fabian Mies, **Mohsen Sadr**, and Manuel Torrilhon. An efficient jump-diffusion approximation of the Boltzmann equation. *Journal of Computational Physics*, 490:112308, 2023.
doi: [10.1016/j.jcp.2023.112308](https://doi.org/10.1016/j.jcp.2023.112308)
7. **Mohsen Sadr**, Alexey Mishchenko, Thomas Hayward-Schneider, Axel Koenies, Alberto Bottino, Alessandro Biancalani, Peter Donnel, Emmanuel Lanti, and Laurent Villard. Linear and nonlinear excitation of TAE modes by external electromagnetic perturbations using ORB5. *Plasma Physics and Controlled Fusion*, 64, 2022.
doi: [10.1088/1361-6587/ac73eb](https://doi.org/10.1088/1361-6587/ac73eb)
8. **Mohsen Sadr**, Marcel Pfeiffer, and M. Hossein Gorji. Fokker-Planck-Poisson kinetics: multi-phase flow beyond equilibrium. *Journal of Fluid Mechanics*, 920, 2021.
doi: [10.1017/jfm.2021.461](https://doi.org/10.1017/jfm.2021.461)
9. **Mohsen Sadr**, Qian Wang, and M. Hossein Gorji. Coupling kinetic and continuum using data-driven maximum entropy distribution. *Journal of Computational Physics*, 444:110542, 2021.
doi: [10.1016/j.jcp.2021.110542](https://doi.org/10.1016/j.jcp.2021.110542)
10. Peter Donnel, Jean Cazabonne, Laurent Villard, Stephan Brunner, Stefano Coda, Joan Decker, Moahan Murugappan, and **Mohsen Sadr**. Quasilinear treatment of wave-particle interactions in the electron cyclotron range and its implementation in a gyrokinetic code. *Plasma Physics and Controlled Fusion*, 63(6):064001, apr 2021.
doi: [10.1088/1361-6587/abf53f](https://doi.org/10.1088/1361-6587/abf53f)
11. **Mohsen Sadr**, Manuel Torrilhon, and M. Hossein Gorji. Gaussian process regression for maximum entropy distribution. *Journal of Computational Physics*, 418:109644, 2020.
doi: [10.1016/j.jcp.2020.109644](https://doi.org/10.1016/j.jcp.2020.109644)
12. **Mohsen Sadr** and M. Hossein Gorji. Treatment of long-range interactions arising in the Enskog-Vlasov description of dense fluids. *Journal of Computational Physics*, 378:129–142, 2019.
doi: [10.1016/j.jcp.2018.11.005](https://doi.org/10.1016/j.jcp.2018.11.005)
13. **Mohsen Sadr** and M. Hossein Gorji. A continuous stochastic model for non-equilibrium dense gases. *Physics of Fluids*, 29, 2017.
doi: [10.1063/1.5004409](https://doi.org/10.1063/1.5004409)
14. Sima Farazi, **Mohsen Sadr**, Seongwon Kang, Martin Schiemann, Nikita Vorobiev, Viktor Scherer, and Heinz Pitsch. Resolved simulations of single char particle combustion in a laminar flow field. *Fuel*, 201, 2017.
doi: [10.1016/j.fuel.2016.11.011](https://doi.org/10.1016/j.fuel.2016.11.011)

Preprints

15. **Mohsen Sadr** and Hossein Gorji. Collision-based dynamics for multi-marginal optimal transport. 2024.
doi: [arXiv:2412.16385](https://arxiv.org/abs/2412.16385)
16. **Mohsen Sadr**, Peyman Mohajerin Esfehani, and M. Hossein Gorji. Optimal transportation by orthogonal coupling dynamics. 2024.
doi: [arXiv:2410.08060](https://arxiv.org/abs/2410.08060)
17. Tony Tohme, Mohammad Javad Khojasteh, **Mohsen Sadr**, Florian Meyer, and Kamal Youcef-Toumi. ISR: Invertible Symbolic Regression. 2024.
doi: [arXiv:2405.06848](https://arxiv.org/abs/2405.06848)

Research Interests

- Diffusion Models, Generative AI, and Optimal Transport
- Kinetic Theory
- Rarefied Gas and Plasma Dynamics
- Variance Reduction for Particle Methods
- Nonequilibrium Multiphase Fluid Flows
- High Performance Computing

Awards & Honors

- 100k CHF Founder Fellowship grant from Paul Scherrer institute and QBIT Capital in 2025.
Title: "*Physics-based Artificial Intelligence: An End-to-End Optimization Platform for Space and Fusion Industries*"
- 1.2m Euro for a project from EUROfusion and SNSF (consortium of national fusion research institutes) in 2021 (associated).
Title: "*Theory, Simulation, Validation and Verification of Burning Plasma*"
- 100k Euro national Walter Benjamin scholarship offered by German research foundation (DFG) in 2020.
Title: "*Multi-scale description of multi-phase fluid flows using data-driven closures*"
- 4k Euro travel grant from German academic exchange service (DAAD) in 2019.
Title: "*Assessment of Fokker-Planck-Poisson approach for near critical multiphase flows*"

Talks & Posters in Conferences

- Particles, Flows & Maps for Sampling Complex Distributions, Lausanne, Switzerland, November 2025.
Poster: "*Collision-based dynamics for optimal transport problem with application in generative models*"
- 5th Mathematical and Scientific Machine Learning, Naples, Italy, August 2025.
Poster: "*Collision-based dynamics for multi-marginal optimal transport*"
- 30th Biennial Numerical Analysis Conference, Glasgow, UK, June, 2025.
Invited talk: "*From Variance Reduction to Density Estimation: Interplay of Entropy and Moments*"
- 4th Mathematical and Scientific Machine Learning, Providence, USA, June 2023.
Poster: "*MESSY Estimation: Maximum Entropy based Stochastic and Symbolic density Estimation*"
- 19th European Fusion Theory Conference, virtual, October 2021.
Posters: "*Convolution based particle solution to Fokker-Planck type equations*"
"*Excitation of TAE modes by an electromagnetic antenna using the global gyrokinetic code ORB5*"
- 9th International Congress on Industrial and Applied Mathematics, Valencia, Spain, July 2019.
Poster: "*Monte-Carlo particle methods for non-equilibrium multiphase flows*"
- 10th International Conference on Multiphase Flow, Rio de Janeiro, Brazil, May 2019.
Talk: "*Stochastic particle approach for non-continuum multiphase flows: a study on inverted temperature gradient*"
- 3rd European Conference on Non-Equilibrium Gas Flows, Strasbourg, France, February 2018.
Talk: "*A Fokker-Planck description of dense fluid flows*"

Relevant Skills

- Programming Knowledge: C, C++, Fortran, Python, PyTorch, TensorFlow, OpenMP, MPI & MATLAB.
- Languages: English (professional), German (basic) & Persian (native).

Review Duties

I am an active reviewer for the following journals:

1. Journal of Computational Physics
2. Physics of Fluids
3. Nature: Scientific Reports
4. Computer Physics Communications
5. Communications in Nonlinear Science & Numerical Simulation
6. International Conference on Learning Representations (ICLR)
7. Advanced Powder Technology
8. Applied Sciences
9. Meccanica
10. Photonics

Extracurricular Activities

- Organizing seminars of Laboratory for Simulation and Modelling at Paul Scherrer Institute (2024).
- Secretary of the Society for Industrial and Applied Mathematics (SIAM) in Aachen (2017-2018).

Lecturing Assistance

ETH, Switzerland

- 2024: Computational Statistical Physics
- Direct Simulation Monte Carlo (DSMC)
 - Variance reduced DSMC
 - Collisions under Coulomb potential
- 2023/24: Introduction to Computational Physics
- Monte Carlo methods
 - Variance reduction
 - Multi Level Monte Carlo method

Teaching Assistance

EPFL, Switzerland

- 2021: Computational Physics 2
- Advection-diffusion equation
 - Schrödinger equation
- 2020/21: Computational Physics 1
- Numerics of nonlinear dynamics
 - Analyzing chaotic systems

RWTH Aachen, Germany

- 2019: Mathematical Foundations 4
- Fundamental solution of PDEs
 - Fourier transformation

2018/19: Mathematical Foundations 5
- Finite volume and element methods
- Hyperbolic conservation laws

2018: Mathematical Foundations 2
- Numerical integration

2017/18: Mathematical Foundations 1
- Linear algebra
- Iterative solvers

Supervised Students

- Caspar Schucan, B.Sc. student, ETH, Switzerland (2025).
- Victor Windhab, M.Sc. student, ETH, Switzerland (2025).
- Alexander Liemen, M.Sc. student, ETH, Switzerland (2024).
- Tony Tohme, Ph.D. student, MIT, Department of Mechanical Engineering, USA (2023).
- Evan Massaro, Ph.D. student, MIT, Department of Mechanical Engineering, USA (2022).
- Felix Wilm, M.Sc. student, RWTH Aachen University, Germany (2019).