Mohsen Sadr

Paul Scherrer Institute,
Accelerator Modelling and Advanced Simulations Group,
CH-5232 Villigen, Switzerland

Building/Room: OHSA/D04
Website: mohsensadr.github.io
GitHub: github.com/mohsensadr

Scientific Appointments

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

2. 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: 10.48550/arXiv.2306.04120.

3. **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.

4. **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.

5. 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.

6. **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.

7. **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.

8. **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.

9. 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.

10. **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.

11. **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.

12. **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.

13. 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.

Preprints

1. **Mohsen Sadr** and Hossein Gorji. Collision-based dynamics for multi-marginal optimal transport. 2024. doi: arXiv:2412.16385.

2. **Mohsen Sadr**, Peyman Mohajerin Esfehani, and M. Hossein Gorji. Optimal transportation by orthogonal coupling dynamics. 2024. doi: arXiv:2410.08060.

3. **Mohsen Sadr**, Tony Tohme, and Kamal Youcef-Toumi. Data-driven discovery of PDEs via the adjoint method. 2024. doi: arXiv:2401.17177.

4. Tony Tohme, Mohammad Javad Khojasteh, **Mohsen Sadr**, Florian Meyer, and Kamal Youcef-Toumi. ISR: Invertible Symbolic Regression. 2024. doi: arXiv:2405.06848.

Research Interests

- Kinetic Theory
- Variance Reduction for Particle Methods

- Monte Carlo Solution Algorithms for Collision Operators
- Data-Driven Modelling
- Machine Learning

Awards & Honors

- Member of the team that won EUROfusion project grant (consortium of national fusion research institutes, EU) in 2021.
  Title: "*Theory, Simulation, Validation and Verification of Burning Plasma*"
- Won the 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*"
- Won the international 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

- 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) & Farsi (native).

Review Duties

I am an active reviewer for the following journals:

1. Journal of Computational Physics
2. Physics of Fluids
3. International Conference on Learning Representations (ICLR)
4. Meccanica
5. 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