Curriculum Vitae

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Robin A. Heinonen
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Research interests:

My primary area of research is the theory of turbulence in fluids and plasmas, with a special focus on the use of machine learning and reinforcement learning tools to solve difficult problems and, where possible, help elucidate the underlying physics. I am increasingly interested in using these data-driven tools to study complex animal behavior, and in particular how it emerges from physical properties and constraints of the environment. Among other topics, I have published work on source tracking in turbulent flows via Bayesian methods, transport model reduction using deep supervised learning, and the analytical theory of turbulent transport and self-organization in magnetized plasmas.

Positions held:

MaLGa, University of Genoa *Mar. 2025 – present*
Postdoctoral fellow

Dept. Physics, University of Rome, "Tor Vergata" *Mar. 2021 – Mar. 2025*
Postdoctoral fellow

Dept. Physics, University of California, San Diego *Apr. 2018 – Feb. 2021*
Graduate research assistant

XCP Division, Los Alamos National Laboratory *Jan. – Aug. 2015*
Post-baccalaureate intern

Education:

University of California, San Diego *Sep. 2015 – Feb. 2021*
Ph.D. Physics (*with computational specialization*); GPA 3.810/4
Thesis Advisor: Patrick H. Diamond
Thesis Title: "Topics in mesoscopic turbulent transport."

University of Minnesota, Twin Cities *Sep. 2010 – Jun. 2014*
B.S. Physics and Mathematics (*magna cum laude*); GPA 3.819/4
Honors Thesis Advisor: Willard Miller, Jr. (deceased)
Thesis Title: "Structure equations for 2D 2nd order superintegrable systems."

Publications:

[**16**] L. Piro, **R. A. Heinonen**, M. Carbone, M. Cencini, and L. Biferale. "Policy heterogeneity improves collective olfactory search in 3-D turbulence." arXiv: 2504.11291 (submitted to *Phys. Rev. Lett.*)

[**15**] **R. A. Heinonen**, L. Biferale, A. Celani, and M. Vergassola. "Exploring Bayesian olfactory search in realistic turbulent flows." arXiv: 2502.21258 (accepted at *Phys. Rev. Fluids*)

[**14**] R. Varennes, Z. Qu, Y. W. Cho, C. Wan, K. Li, **R. A. Heinonen**, and V. Grandgirard. "A robust data-driven approach for modeling turbulent transport." (accepted at *Nucl. Fus.*)

[**13**] L. Piro, **R. A. Heinonen**, M. Cencini, and L. Biferale. "Many wrong models approach to localize an odor source in turbulence with static sensors." *J. Turbul.*, 1–21 (2025).

[**12**] **R. A. Heinonen**, L. Biferale, A. Celani, and M. Vergassola. "Optimal trajectories for Bayesian olfactory search in turbulent flows: The low-information limit and beyond." *Phys. Rev. Fluids* **10**, 044601 (2025).

[**11**] **R. A. Heinonen**, L. Biferale, A. Celani, and M. Vergassola. "Optimal policies for Bayesian olfactory

search in turbulent flows." *Phys. Rev. E* **107**, 055105 (2023).

[**10**] A. Loisy and **R. A. Heinonen**. "Deep reinforcement learning for the olfactory search POMDP: a quantitative benchmark." *Euro. Phys. J. E* **46**, 17 (2023).

[**9**] **R. A. Heinonen**, P. H. Diamond, M. F. D. Katz, and G. E. Ronimo. "Generation of momentum transport in weakly turbulent β-plane magnetohydrodynamics." *Phys. Rev. E* **107**, 025202 (2023).

[**8**] O. Heinonen, **R. A. Heinonen**, and H. Park. "Magnetic ground states of a model for $M\mathrm{Nb}_3\mathrm{S}_6$ (M = Co, Fe, Ni)." *Phys. Rev. Mat.* **6**, 024405 (2022).

[**7**] **R. A. Heinonen** and P. H. Diamond. "Learning how structures form in drift-wave turbulence." *Plasma Phys. Control. Fusion* **62**, 105017 (2020).

[**6**] **R. A. Heinonen** and P. H. Diamond. "Turbulence model reduction by deep learning." *Phys. Rev. E* **101**, 061201(R) (2020).

[**5**] **R. A. Heinonen**, D. Saumon, J. Daligault, C. E. Starrett, S. D. Baalrud, and G. Fontaine. "Diffusion coefficients in the envelopes of white dwarfs." *Astrophys. J.* **896.1**, 2 (2020).

[**4**] **R. A. Heinonen** and P. H. Diamond. "A closer look at turbulence spreading: How bistability admits intermittent, propagating turbulence fronts." *Phys. Plasmas* **27**, 032303 (2020).

[**3**] **R. A. Heinonen** and P. H. Diamond. "Subcritical turbulence spreading and avalanche birth." *Phys. Plasmas* **26**, 030701 (2019).

[**2**] N. M. Gill, **R. A. Heinonen**, C. E. Starrett, and D. Saumon. "Ion-ion dynamic structure factor of warm dense mixtures." *Phys. Rev. E* **91**, 063109 (2015).

[**1**] **R. A. Heinonen**, E. G. Kalnins, W. Miller, Jr., and E. Subag. "Structure relations and Darboux contractions for 2D 2nd order superintegrable systems." *SIGMA* **11**, 043 (2015).

Conference talks:

[**16**] EFDC (2024). "Bayesian olfactory search in realistic turbulent flows."

[**15**] APS-DFD (2023). "Optimal Bayesian olfactory search in a realistic turbulent flow."

[**14**] ETC (2023). "Optimal policies for Bayesian olfactory search in a turbulent flow."

[**13**] APS-DFD, (2022). "Data-driven Bayesian olfactory search in a turbulent flow."

[**12**] EFMC (2022). "Optimal policies for Bayesian olfactory search in a turbulent environment."

[**11**] Festival de Théorie (2022) "Optimal policies for olfactory search in a turbulent environment using POMDP."

[**10**] APS-DFD, (2021). "Search strategies in a turbulent flow using a POMDP framework."

[**9**] AAPPS-DPP, invited (2021). "On the role of cross-helicity in β-plane MHD turbulence."

[**8**] Euromech Colloquium 614, "Machine learning methods for prediction and control of turbulent flows" (2021). "Learning how structures form in drift-wave turbulence."

[**7**] APS-DPP (2020). "On the role of cross-helicity in β-plane MHD turbulence."

[**6**] APS-DPP (2020). "Turbulence model reduction by deep learning."

[**5**] AAPPS-DPP, invited (2020). "Turbulence model reduction by deep learning."

[**4**] Transport Task Force (2020). "Turbulence model reduction by deep learning" (cancelled due to COVID-19).

[**3**] APS-DPP, invited (2019). "Subcritical turbulence spreading and avalanche birth."

[**2**] APS-DPP, (2019). "Learning a model for mean-field turbulence dynamics."

[**1**] Festival de Théorie (2019). "Subcritical turbulence spreading and avalanche birth."

Conference posters:

[**5**] Transport Task Force (2019). "Learning mean field dynamics of drift-wave turbulence."

[**4**] APS-DPP (2018). "A closer look at turbulence spreading: how bistability admits intermittent, propagating turbulence pulses."

[**3**] Chengdu Theory Festival (2018). "A closer look at turbulence spreading: how bistability admits intermittent, propagating turbulence pulses."

[**2**] Transport Task Force (2018). "A closer look at turbulence spreading: how bistability admits intermittent, propagating turbulence pulses."

[**1**] LANL 15th Annual Student Symposium (2015). "Coefficients of diffusion in dense stellar plasmas."

Seminars:

[**3**] *Phys. Rev. Fluids* Journal Club (2025). "Optimal olfactory search in turbulent flows."

[**2**] Invited seminar, University of California, Santa Barbara (2023). "Optimal policies for Bayesian olfactory search in a turbulent flow."

[**1**] Young Seminars SIFS, Italian Society of Statistical Physics (2023). "Optimal policies for Bayesian olfactory search."

Selected awards/honors:

- Invited Talk, *Phys. Rev. Fluids* Journal Club ("Optimal trajectories for Bayesian olfactory search in turbulent flows: The low-information limit and beyond"), 2025
- *Phys. Rev. Fluids* Editor's Suggestion ("Optimal trajectories for Bayesian olfactory search in turbulent flows: The low-information limit and beyond"), 2025
- Invited Talk, AAPPS-DPP ("On the role of cross-helicity in β-plane MHD turbulence"), 2021
- Invited Talk, AAPPS-DPP ("Turbulence model reduction by deep learning"), 2020
- Invited Talk, APS-DPP ("Subcritical turbulence spreading and avalanche birth"), 2019
- Fellow, Aix-en-Provence Festival de Théorie, 2019
- *Physics of Plasmas* Featured Article and Scilight ("Subcritical turbulence spreading and avalanche birth"), 2019
- Fellow, LANL Computational Physics Student Summer Workshop, 2014
- Phi Beta Kappa, 2014
- Hans H. Dalaker Scholarship in Mathematics, 2012 & 2013
- Alfred O. C. Nier Scholarship in Physics, 2012

Peer review:

Referee for *Physical Review E*, *Nuclear Fusion*, *Physics of Plasmas*, *Machine Learning: Science and Technology*, *Nonlinear Dynamics*, *EPL*, and *Communications Physics*.

Erdős number: 3

Via W. Miller, Jr., and L. A. Rubel.