Julian Arnold

Curriculum Vitae (Date: May 29, 2024)

Department of Physics
University of Basel
Klingelbergstrasse 82, office 4.10
CH-4056 Basel, Switzerland
✉ *julian.arnold@unibas.ch*

Personal Information

origin	Swiss, born in Unterschächen (CH) on 7 September 1998
group page	quantumtheory-bruder.physik.unibas.ch
personal page	arnoldjulian.github.io

Education and Degrees

08/2021 –present
University of Basel, PhD Candidate in Theoretical Physics.
Focus: Machine learning in physics, supervisor: Prof. Christoph Bruder.

08/2019 –03/2021
University of Basel, Master of Science in Nanosciences, *final grade: 5,8/6,0*.
External Master thesis at Institute for Theoretical Physics, **ETH Zurich**: "Entropy production in ticking clocks", supervised by Dr. Mischa Prebin Woods, Prof. Christoph Bruder, and Prof. Renato Renner.

09/2016 –07/2019
University of Basel, Bachelor of Science in Nanosciences, *final grade: 5,7/6,0*.
Highlighted research project: "Magneto-optical trapping of ^{87}Rb using an interference filter-stabilized external cavity diode laser", supervised by Prof. Philipp Treutlein.

08/2010 –06/2016
Kantonsschule Seetal, Matura, Matura thesis prize (best Matura thesis in natural sciences of the year), *final grade: 5,2/6,0*.
Matura thesis: "Influence of electrolytes on the electric properties of a dye-sensitized solar cell", supervised by Dr. Martin Jufer.

Distinctions and Awards

2023 Distinguished student award for the APS March Meeting

2023 Camille- and Henry-Dreyfus scholarship

2022 Best poster award for *Entropy production in ticking clocks: Fundamental limits of time-keeping*, 761. WE-Heraeus-Seminar on Entropy and the Second Law of Thermodynamics

2017 Swiss national science competition "Schweizer Jugend forscht" – Predicate: good

2016 Special award of technology, Lucerne School of Engineering and Architecture

2016 Award for the best Matura thesis in natural sciences, Kantonsschule Seetal

Publications

Total citations = 140+, h-index = 5 (as of 05/2024) [Source: Google Scholar]

Preprints

[12] **Julian Arnold**, Flemming Holtorf, Frank Schäfer, and Niels Lörch, *Detecting Phase Transitions in Large Language Models*, arXiv:2405.17088 (2024).

[11] **Julian Arnold**, Flemming Holtorf, Niels Lörch, and Frank Schäfer, *Machine learning phase transitions: Connections to the Fisher information*, arXiv:2311.10710 (2023).

Peer-reviewed Publications

[10] Flemming Holtorf, Frank Schäfer, **Julian Arnold**, Christopher Rackauckas, and Alan Edelman, *Performance Bounds for Quantum Control*, arXiv:2304.03366 (2023) [accepted in IEEE TAC].

[9] **Julian Arnold**, Frank Schäfer, and Niels Lörch, *Fast Detection of Phase Transitions with Multi-Task Learning-by-Confusion*, NeurIPS 2023 Machine Learning and the Physical Sciences Workshop (2023).

[8] **Julian Arnold**, Frank Schäfer, Alan Edelman, and Christoph Bruder, *Mapping out phase diagrams with generative classifiers*, Phys. Rev. Lett. **132**, 207301 (2024) [featured in press release by MIT and University of Basel].

[7] Anna Dawid, **Julian Arnold** *et al.*, *Modern applications of machine learning in quantum sciences*, arXiv:2204.04198 (2022) [A comprehensive set of lecture notes in press as a book at Cambridge University Press].

[6] Axel U. J. Lode, Ofir E. Alon, **Julian Arnold** *et al.*, *Quantum simulators, phase transitions, resonant tunneling, and variances: A many-body perspective*, In: Nagel, W.E., Kröner, D.H., Resch, M.M. (eds) High Performance Computing in Science and Engineering '21, HPCSE 2021, Springer (2023).

[5] Juan Carlos S. V. Veliz, **Julian Arnold**, Raymond J. Bemish, and Markus Meuwly, *Combining Machine Learning and Spectroscopy to Model Reactive Atom + Diatom Collisions*, J. Phys. Chem. A **126**, 7971 (2022).

[4] **Julian Arnold** and Frank Schäfer, *Replacing neural networks by optimal analytical predictors for the detection of phase transitions*, Phys. Rev. X **12**, 031044 (2022) [featured in press release.

[3] **Julian Arnold**, Juan Carlos S. V. Veliz, Debasish Koner, Narendra Singh, Raymond J. Bemish, and Markus Meuwly, *Machine learning product state distributions from initial reactant states for a reactive atom–diatom collision system*, J. Chem. Phys. **156**, 034301 (2022).

[2] **Julian Arnold**, Frank Schäfer, Martin Žonda, and Axel U. J. Lode, *Interpretable and unsupervised phase classification*, Phys. Rev. Res. **3**, 033052 (2021).

[1] **Julian Arnold**, Debasish Koner, Silvan Käser, Narendra Singh, Raymond J. Bemish, and Markus Meuwly, *Machine Learning for Observables: Reactant to Product State Distributions for Atom-Diatom Collisions*, J. Phys. Chem. A **124**, 7177 (2020).

Seminar & Conference Contributions

Invited Seminar Talks

03/2024 **National University of Singapore**, Centre for Quantum Technologies, QAISG QML Seminar (organizers: Gan Beng Yee *et al.*), *Mapping out phase diagrams with generative classifiers* – online.

07/2023 **Max Planck Institute for the Science of Light**, Theory Division Seminar (organizer: Prof. Florian Marquardt), *Replacing neural networks by optimal analytical predictors for the detection of phase transitions* – Erlangen (Germany).

02/2023 **Perimeter Institute**, Perimeter Institute Quantum Intelligence Lab Group Seminar (organizer: Prof. Roger Melko), *Replacing neural networks by optimal analytical predictors for the detection of phase transitions* – online.

12/2022 **University of Basel**, QCQT Seminar (organizer: Prof. Jelena Klinovaja) *Replacing neural networks by optimal analytical predictors for the detection of phase transitions* – Basel (Switzerland).

11/2022 **University of Basel**, Seminar in Probability Theory and Statistics (organizers: Prof. Jiří Černý and Prof. David Belius), *Replacing neural networks by optimal analytical predictors for the detection of phase transitions* – Basel (Switzerland).

08/2022 **Heinrich Heine Universität Düsseldorf**, seminar in the group of Prof. Martin Kliesch, *Replacing neural networks by optimal analytical predictors for the detection of phase transitions* – Düsseldorf (Germany).

05/2022 **ultracold.org**, Journal Club for Quantum Physics and Machine Learning (organizers: MCTDH-X team), *Replacing neural networks by optimal analytical predictors for the detection of phase transitions* – online.

04/2022 **ICFO**, seminar in the group of Prof. Maciej Lewenstein, *Replacing neural networks by optimal analytical predictors for the detection of phase transitions* – online.

02/2022 **TU Delft**, seminar in the group of Prof. Eliska Greplova, *Replacing neural networks by optimal analytical predictors for the detection of phase transitions* – online.

03/2021 **ETH Zurich**, seminar in the group of Prof. Renato Renner, *Entropy production in ticking clocks* – online.

01/2021 **ultracold.org**, Journal Club for Quantum Physics and Machine Learning (organizers: MCTDH-X team), *Interpretable and unsupervised phase classification* – online.

Contributed Talks (*) indicates delivery by co-author

09/2023 **Joint Annual Meeting of SPS and ÖPG 2023**, *Mapping out phase diagrams using generative classifiers* – Basel (Switzerland).

07/2023 **JuliaCon 2023**, *Machine learning phase transitions: A probabilistic framework* – Cambridge (USA).

07/2023 **JuliaCon 2023**, *Differentiable isospectral flows for matrix diagonalization* – Cambridge (USA).

*07/2023 **JuliaCon 2023**, *Performance bounds for quantum control* – Cambridge (USA).

03/2023 **APS March Meeting 2023**, *Revealing phase diagrams of quantum systems with optimal predictors* – Las Vegas (USA).

*03/2023 **APS March Meeting 2023**, *How deep neural networks learn thermal phase transitions* – Las Vegas (USA).

03/2022 **AMLD 2022**, *Replacing neural networks by optimal analytical predictors for the detection of phase transitions* – Lausanne (Switzerland).

03/2021 **APS March Meeting 2021**, *Interpretable and unsupervised phase classification based on averaged input features* – online.

Posters (*) indicates delivery by co-author

01/2024 **Quantum Information Processing (QIP) 2024**, *Machine learning phase transitions: Connections to the Fisher information* – Taipei (Taiwan).

12/2023 **NeurIPS 2023: Machine Learning and the Physical Sciences Workshop**, *Fast Detection of Phase Transitions with Multi-Task Learning-by-Confusion* – New Orleans (USA).

*09/2023 **2023 IEEE International Conference on Quantum Computing and Engineering (QCE)**, *Sum-of-Squares Bounds for Quantum Optimal Control* – Bellevue, Washington (USA).

07/2023 **Alan Edelman's 60th Birthday Conference**, *Performance bounds for quantum control* – Cambridge (USA).

09/2022 **Arnold Sommerfeld School: Physics Meets Artificial Intelligence**, *Optimal analytical predictions of machine learning methods for the detection of phase transitions* – Munich (Germany).

07/2022 **761. WE-Heraeus-Seminar on Entropy and the Second Law of Thermodynamic**, *Entropy production in ticking clocks: Fundamental limits of timekeeping* – Bad Honnef (Germany).

02/2022 **NCCR QSIT Winter School & NCCR QSIT General Meeting**, *Optimal analytical predictions of machine learning methods for the detection of phase transitions* – Arosa (Switzerland).

09/2021 **QUSTEC Summer School**, *Interpretable and unsupervised phase classification* – Engelberg (Switzerland).

08/2021 **Summer School: Machine Learning in Quantum Physics and Chemistry**, *Interpretable and unsupervised phase classification* – Warsaw (Poland).

06/2021 **Workshop on Artificial Scientific Discovery 2021**, *Interpretable and unsupervised phase classification* – online.

Visibility in Media

05/2024 **Massachusetts Institute of Technology**, Scientists use generative AI to answer complex questions in physics. MIT press release on the paper *Mapping Out Phase Diagrams with Generative Classifiers*.

05/2024	**University of Basel**, Artificial intelligence calculates phase diagrams. University press release on the paper *Mapping Out Phase Diagrams with Generative Classifiers*.
09/2022	**University of Basel**, Computational shortcut for neural networks. University press release on the paper *Replacing neural networks by optimal analytical predictors for the detection of phase transitions*.
03/2016	**Seetaler Bote**, Mit Wissenschaft Wissen geschaffen. Local newspaper reporting on my Matura thesis on *Grätzel-Zelle – Einfluss des Elektrolyten auf die elektrischen Eigenschaften einer Grätzel-Zelle*.
03/2016	**Schweizer Radio und Fernsehen (SRF)**, Beste Maturaarbeiten ausgezeichnet. National newsstation mentions prize for my Matura thesis on *Grätzel-Zelle – Einfluss des Elektrolyten auf die elektrischen Eigenschaften einer Grätzel-Zelle*.

Supervising, Teaching, Tutoring, and Reviewing

04/2021 – present	**University of Basel**, *Supervising*. I co-supervised three Master students on • Jan Neuser: Numerical quantum gate design for superconducting qubits (01/2023 – 04/2023) • Heinz Krummenacher: Diagonalisation of quantum many-body systems by flow equations (03/2022 – 01/2023) • Benjamin Senn: Unsupervised approaches for the identification of phase transitions in the swarmalator model (04/2021 – 02/2022)
01/2022 – present	**University of Basel**, *Teaching*. During the spring term 2022 I conceived a 2-week intensive course on quantum computing for Bachelor and Master students. I taught the course during summer 2022 and 2023. During the spring term 2024 I conceived a 2-week intensive course on contemporary machine learning for physicists. I taught the course during summer 2024. Moreover, I replaced Christoph Bruder in a lecture on quantum mechanics aimed at Bachelor students.
09/2021 –present	**University of Basel**, *Tutoring*. Tutoring Bachelor students from physics, computational science, and nanosciences: • Classical and quantum nonlinear dynamics, spring term 2024 (student evaluation: xx/xx) • Theory of superconductivity, spring term 2023 (student evaluation: 5,7/6,0) • Classical mechanics, fall term 2022 (student evaluation: 5,8/6,0) • Quantum mechanics, fall term 2021 (student evaluation: 5,2/6,0)
02/2022 – present	**Professional service**. Independent peer-review for • Physical Review A, B, E, Research, Letters, PRX Quantum • New Journal of Physics, Machine Learning: Science and Technology [Trusted reviewer status] • IEEE Control Systems Letters (L-CSS), American Control Conference (ACC), IEEE Conference on Decision and Control (CDC) • NeurIPS

Practical Experience

08/2023	**University of Basel**, Organization of scientific workshop. Co-organizing a 1-day workshop on "Scientific Machine Learning and Stochastic Optimal Control" at the department of physics.
04/2022 –present	**University of Basel**, Computer administrator of Bruder group. Responsible among other things for maintaining group website, distributing software, installing Linux operating systems, ordering computers and IT accessories, and tackling security vulnerabilities.
02/2022 –present	**The Julia Language**, Open-source software development. Developing scientific open-source software packages in the Julia programming language.

Additional Qualifications

Scientific computing.
Julia, Python, Mathematica, git

High-performance computing.
Linux, Slurm, shell scripting

Technical writing and presentation.
LaTeX, Microsoft Word and PowerPoint, Inkscape

Languages.
German (Native), English (Fluent), French (Level B2), Spanish (Level B2)

Social Engagement and Outreach

03/2023
–present
Quantum mechanics at elementary schools.
I regularly give a first introduction to quantum phenomena at nearby Swiss elementary schools through interactive experiments illustrating the wave–particle duality.

01/2023
–04/2023
Climate protection initiative, Department of Physics, University of Basel.
Member of an ad-hoc team that assesses the current CO_2 emission of the department, communicates results to the public, and proposes new sustainability policies.

Institutional Responsibilities

06/2023
–present
PhD representative, Department of Physics, University of Basel.
Board member of the PhD Association Physics Basel responsible for representing the interests of PhD students in departmental meetings.

02/2023
Scientific advisory board PhD session, Department of Physics, University of Basel.
Participation in scientific advisory board session focusing on doctoral education and PhD students.

11/2021
–10/2022
PhD survey, Department of Physics, University of Basel.
Member of support group establishing a PhD survey at the department together with the graduate center of the University of Basel.