Neco Kriel

Contact Information

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Accounts:	GitHub • Google Scholar • ResearchGate • OrcID
Affiliation:	Research School of Astronomy and Astrophysics (RSAA), Australian National University (ANU), Australian Capital Territory, 2611, Australia
Interests:	turbulent plasma/fluid dynamics • mathematical modelling • high performance computing

Education

Doctor of Philosophy at the Australian National University

2022 – Present (Exp. Aug. 2025) | *Specialisation:* Theoretical & Computational Astrophysics
Supervisors: Professor Mark Krumholz

Honours in Science (First Class) at the Australian National University

2021 | *Major:* Astronomy & Astrophysics
Thesis: Fundamental magnetohydrodynamic (MHD) scales in small-scale dynamos.

Bachelor & Honours (First Class) **in Engineering** at Queensland University of Technology (QUT)

2016 – 2020 | *Major:* Computer & Software Systems
Thesis: Improved modelling of turbulence in agrichemical spray simulations.

Bachelor in Mathematics at Queensland University of Technology

2016 – 2019 | *Major:* Applied & Computational Mathematics

Exchange Programs

2022 | International School for Space Simulations in Kyoto, Japan

2019 | Internship (3 months) at the Institute of Mathematical Stochastics, Technische Universität Dresden
Summary: *Studied the properties of particles that randomly move (i.e., Brownian motion) around in space, and how their trajectories depend on external conditions like wind-drafts and boundaries.*

2018 | Internship (5 months) at the Optical Materials Photonics and Systems Laboratory, CentraleSupélec
Summary: *Simulated laser-beams to understand how chaos can be generated and controlled in semiconductor lasers with (phase-conjugate) feedback.*

| Photonics & Data Science Summer School at the Technical University of Turin

Scholarships & Awards

2022 – 2025 Australian Government Research Training Scholarship
2022 Joan Duffield Research Award
2021 RSAA Bok Honours Year Scholarship
2017 – 2020 Admission to the Dean's List of Academic Excellence at QUT
2019 Dresden University of Technology Research Scholarship
2018 Nicolas Baudin Research Travel Grant

Professional Presentations

- 3 Invited Talks
  [26th Mar. 2024] ASA ECR Symposium Series, University of Southern Queensland
  [14th Nov. 2023] Plasma physics research group, Canadian Institute for Theoretical Astrophysics
  [7th Feb. 2023] Virtual Nordic Dynamo Seminar, Stockholm University
- 5 Conference Talks
  [17th Jul. 2023] Interstellar Institute 6 Meeting, Institut Pascal
  [14th Apr. 2023] IMAGINE meeting, Nordic Institute for Theoretical Physics
  [9th Dec. 2021] The Australian Institute of Physics
  [8th Oct. 2021] Specialist Meeting on Galactic magnetic fields, The Royal Astronomical Society
  [17th Sep. 2021] The Australasian Conference of Undergraduate Research

- 4 Outreach Talks
  [30th Nov. 2023] Open Day at Siding Springs Observatory
  [5th Mar. 2021] Feast of Facts, RSAA, ANU
  [Semester 1 2020] Two lectures to the year 12 Advanced Mathematics cohort at my former high school.

Professional Service

Peer-review Contributions

2022 | One article in Monthly Notices of the Astronomical Society on the small-scale dynamo.

Community Involvement

2023 | • Chair of the Seminar Committee at the RSAA
Key Tasks: *Organised 80+ speakers' visits, scheduled the team of 8's hosting duties, managed annual budget of $10,000 AUD, and hosted 20+ seminars.*

| • Organiser of the weekly journal club ('astro-coffee') at the RSAA

| • Co-organiser of the student writing retreat at the RSAA

2022 | • Organising Committee Chair for the Mount Stromlo Student Seminars

2018 – 2020 | STIMULATE Peer Learning Facilitator at QUT

Public Outreach

2022 – Present | Stargazing guide at Mount Stromlo Observatory

2018 – 2020 | STEM Widening Participation Ambassador at QUT

Teaching Experience

- Two invited guest lectures to graduate level students.
  [13th Oct. 2022] '*The small-scale dynamo*' for a course on astrophysical gas dynamics at ANU.
  [7th Oct. 2020] '*Data reduction & the curse of dimensionality*' for a final-year data science course at QUT.
- Taught six undergraduate courses spanning advanced courses like Partial Differential Equations through to Visualising Scientific Data at QUT.

  Programming topics: *Computational Programming* (MATLAB, Python), *Statistical Analysis & Geospatial Visualisations* (R-programming language), programming a Raspberry Pi

  Math topics: *Fourier Analysis, Matrices, ODEs & PDEs, Vector Calculus*

Technical Experience

Programming Languages / Tools

Advanced:	C++ (AMReX, CUDA), Git, LaTeX, MATLAB, Python, Visit	*Weapons of choice.*
Intermediate:	C, C++ (OpenMP, MPI), C#, Java, Mathematica, R	*Experienced with.*
Basic:	Blender (data visualisation), FORTRAN	*Still learning.*

Software Development

- QUOKKA (developer of the MHD-module)

  Summary: *In progress. QUOKKA is a multiphysics, GPU accelerated, adaptive mesh refinement, astrophysical simulation code written in C++17. I implemented all the infrastructure to track quantities on a staggered-grid (cell faces), as well as the solver to evolve ideal MHD physics: a constrained transport (CT) scheme (conserves an absence of magnetic monopoles, viz. $\nabla \cdot \vec{b} = \vec{0}$, to machine precision) along with a HLLD solver (a popular Riemann solver for MHD; resolves all discontinuities in the plasma by construction).*

- I like to create small creative code-projects that make use of cool math/algorithms. See here for examples.

  Topics: *path optimisation* in a 3D network, rendering with *signed-distance functions*, *search algorithms* for decision making, *gradient descend* on surfaces, etc.

Publications

• **Citations:** 38 • **h-index:** 4

Peer Reviewed (First Author)

1. Kriel, N., Beattie, J. R., Seta, A., & Federrath, C. (2022). Fundamental scales in the kinematic phase of the turbulent dynamo. DOI: 10.1093/mnras/stac969. arXiv: 2204.00828.

   Key Tasks: *Ran all simulations (3.5 MSU), developed spectral models and fitting algorithms, performed all data analysis (∼ 100 terabytes), and wrote the manuscript.*

Peer Reviewed (Main Contributor)

1. Beattie, J. R., Federrath, C., Kriel, N., Mocz, P., & Seta, A. (2023). Growth or Decay – I: universality of the turbulent dynamo saturation. DOI: 10.1093/mnras/stad1863. arXiv: 2209.10749.

   Key Contributions: *Helped develop the theoretical methodology, and draft the manuscript.*

Peer Reviewed (Large Collaboration)

1. Beattie, J. R., Krumholz, M., Skalidis, R., Federrath, C., Mocz, P., Crocker, R. M., Seta, A., & Kriel, N. (2022). Energy balance and Alfvén Mach numbers in compressible magnetohydrodynamic turbulence with a large-scale magnetic field. DOI: 10.1093/mnras/stac2099. arXiv: 2202.13020.

Submitted & Under Review

1. Kriel, N., Beattie, J. R., Federrath, C., Krumholz, M. R., & Hew, J. (submitted October 2023). Fundamental MHD scales – II: the kinematic phase of the supersonic small-scale dynamo. *arXiv preprints*. arXiv: 2310.17036.

   Key Tasks: *Ran all simulations (5 MSU), developed all theoretical models and computational algorithms (including an improved stencil for computing field-line curvature statistics that guarantees exact accuracy to machine precision; Appendix E), performed all data analysis (∼ 10 petabytes), and wrote the manuscript.*

2. Beattie, J. R., Federrath, C., Kriel, N., Hew, J. (submitted December 2023). Taking control of compressible modes: bulk viscosity and the compressible turbulent dynamo. *arXiv preprints*. arXiv: 2312.03984.

   Key Contributions: *Helped derive the magnetic energy equation (Appendix B), with the development of the theoretical model for coupling between compressible and solenoidal kinetic modes, and draft the manuscript.*

In Preparation

1. Beattie, J. R., Federrath, C., Kriel, N., Mocz, P., Hew, J., & Ripperda, B. (Expected 2024.Q1 submission). Growth or Decay – II: sub-Alfvénic plasmoidal decay into driven turbulence.

2. Hew, J., Hosking, D. N., Federrath, C., Beattie, J. R., Kriel, N., & Seta, A. (Expected 2024.Q1 submission). Exact von-Kármán-Howarth scaling relations for the Hosking integral in non-helical magnetohydrodynamic turbulence.

3. Kriel, N., Krumholz, M. R., Wibking, B., & Li, P. S. (Expected 2024.Q3 submission). Small-scale magnetic field generation in the interstellar medium.

   Key Tasks: *Implemented all the C++17 code to simulate magnetic field physics (ideal MHD physics), rigorously tested the solver's stability, accuracy and scalability, and wrote the code release manuscript.*

4. Kriel, N., Krumholz, M. R., James R. Beattie. (Expected 2024.Q3 submission). Curvature statistics of magnetic fields in compressible, Alfvénic plasmas.

5. Beattie, J. R., Kriel, N.. (Expected 2024.Q3 submission). Relax & grow-up: the minimum energy state of magnetic fields in small-scale dynamos

Non-Peer Reviewed

1. Beattie, J. R., Kriel, N. (2019). Is The Starry Night Turbulent?. *arXiv preprints*. arXiv: 1902.03381.

   Key Contributions: *Implemented a second-order structure function to measure how correlated pixel intensities are as a function of scale-separation in Van Gogh's Starry Night painting, and helped draft the manuscript.*