

## Skill set

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- \* Formal verification in maths and physics: Develop and maintain ‘HepLean’, a project to digitalise results from high energy physics into Lean 4. One motivation behind this is to develop a new way to use AI in theoretical physics.
- \* Categorical methods: 5 peer-reviewed publications using (higher) category theory to understand problems in physics. More generally, a range of publications applying advanced mathematics to physics.
- \* Theoretical physics: PhD from University of Cambridge, Masters/Undergrad from University of Oxford.
- \* Computer programming: 6+ years of experience in C++, python, Mathematica and Github.
- \* Software development skills: Contributed to a large open-source project (Mathlib). Maintain an open-source Github repository.
- \* Science communication: Ran and organised many outreach events communicating science to the wider public.

## Employment

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- PostDoc. **Reykjavik University** (2024-current), Computer Science.  
[Postdoc-Advisor](#): Tarmo Uustalu
- PostDoc. **Cornell University** (2021-2024), High energy physics.  
[Position](#): Hans Bethe Postdoctoral Associate in the high-energy theory group in the Cornell Laboratory for Accelerator-based Sciences and Education (CLASSE)  
[Description](#): Started a program to digitalise results from high energy physics into Lean 4. Also, continued use of higher category theory in physics by studying generalized symmetries.

## Education

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- PhD. **University of Cambridge** (2018-2021), Mathematical and Theoretical Physics.  
[Thesis](#): Arithmetical, geometrical, and categorical forays into particle physics.  
[Description](#): Thesis focused on the application of techniques in mathematics to solve problems in physics, including the use of number theory, category theory and geometry.  
[Advisor](#): Ben Gripaios  
[Awards](#): Honorary Vice-Chancellors Award (2018)
- MMathPhys. **University of Oxford** (2014-2018), Mathematical and Theoretical Physics.  
[Classification](#): Distinction/First Class (double classification)  
[Awards \(Christ Church College\)](#): \* Scholarships (2024-2017) \* Collections Prize (2016) \* Clifford Smith Prize (2018) \* Hooke Prize (2018)  
[Awards \(University of Oxford\)](#): \* The Scott Prize for performance in the Physics Part A examination (2016) \* The Scott Prize for best performance in the MPhys Part B examination (2017) \* Prize for the [Best Results](#) on the Oxford MMathPhys (2018)

## Three most important publications

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I list below those papers I deem the most important. Due to the different citation conventions amongst the fields I have published in, these are not necessarily my papers with the most citations.

- \* J. Tooby-Smith. [HepLean: Digitalising high energy physics](#). In: *arXiv preprint* (2024). arXiv:2405.08863 [hep-ph].

This paper detailed a project called "HepLean", to create a monolithic library in the theorem prover Lean 4 containing results from the area of high energy physics. High energy physics is probably the closest area of physics to mathematics. This is a project I'm continuing to work on. Most physicists use computer algebra systems (e.g. mathematica), I am planning to make Lean and the library HepLean as useable as possible for physicists.

- \* B. Gripaios, O. Randal-Williams, and J. Tooby-Smith. [Smooth generalized symmetries of quantum field theories](#). In: *J. Geom. Phys.* 201 (2024), 105212. doi:10.1016/j.geomphys.2024.105212. arXiv:2310.16090 [hep-th].

The area of category theory is a common language between mathematics, computer science and physics. In this paper we used a special area of category theory called higher topos theory to formulate a concept in physics called generalized symmetries. This used a generalisation of the notion of a monad (which will be familiar to functional computer scientists).

- \* B. C. Allanach, B. Gripaios, and J. Tooby-Smith. [Semisimple extensions of the Standard Model gauge algebra](#). In: *Phys. Rev. D* 104.3 (2021), 035035.

This paper answered the question: Given the elementary particles we know which make up the universe, what are the allowed forces (e.g. the strong nuclear-force) we can have? With suitable constraints this question has a finite answer, which can be found using a computer program based on category theory, and combinatorics. This paper was published around 3 years ago and was written in C++. My approach today would be to use Lean or another theorem proving software to ensure correctness.

## Other publications

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- \* A. Gomes, M. Ruhdorfer, and J. Tooby-Smith. [Semisimple unifications of any gauge theory](#). In: *Phys. Rev. D* 108.7 (2023), 075001. doi:10.1103/PhysRevD.108.075001. arXiv:2306.16439 [hep-ph].
- \* C. Csaki, A. Ismail, M. Ruhdorfer, and J. Tooby-Smith. [Higgs squared](#). In: *JHEP* 04 (2023), 082. doi:10.1007/JHEP04(2023)082. arXiv:2210.02456 [hep-ph].
- \* B. Gripaios, O. Randal-Williams, and J. Tooby-Smith. [Generalized symmetries of topological field theories](#). In: *JHEP* 03 (2023), 087. doi:10.1007/JHEP03(2023)087. arXiv:2209.13524 [hep-th].
- \* J. Davighi and J. Tooby-Smith. [Flatland: abelian extensions of the Standard Model with semi-simple completions](#). In: *JHEP* 09 (2022), 159. doi:10.1007/JHEP09(2022)159. arXiv:2206.11271 [hep-ph].
- \* J. Davighi and J. Tooby-Smith. [Electroweak flavour unification](#). In: *JHEP* 09 (2022), 193. doi:10.1007/JHEP09(2022)193. arXiv:2201.07245 [hep-ph].
- \* B. C. Allanach, M. Madigan, and J. Tooby-Smith. [A  \$\nu\$  supersymmetric anomaly-free atlas](#). In: *JHEP* 02 (2022), 144. doi:10.1007/JHEP02(2022)144. arXiv:2107.07926 [hep-ph].
- \* J. Tooby-Smith. [Arithmetical, geometrical, and categorical forays into particle physics](#). In: *Preprint* (2021). doi:10.17863/CAM.72061.
- \* B. Gripaios and J. Tooby-Smith. [Inverse Higgs phenomena as duals of holonomic constraints](#). In: *J. Phys. A* 55.9 (2022), 095401. doi:10.1088/1751-8121/ac4c66. arXiv:2103.08923 [hep-th].
- \* J. Davighi, M. McCullough, and J. Tooby-Smith. [Undulating Dark Matter](#). In: *JHEP* 11 (2020), 120. doi:10.1007/JHEP11(2020)120. arXiv:2007.03662 [hep-ph].
- \* B. C. Allanach, B. Gripaios, and J. Tooby-Smith. [Anomaly cancellation with an extra gauge boson](#). In: *Phys. Rev. Lett.* 125.16 (2020), 161601. doi:10.1103/PhysRevLett.125.161601. arXiv:2006.03588 [hep-th].
- \* T. Cohen, N. Craig, S. Koren, M. McCullough, and J. Tooby-Smith. [Supersoft Top Squarks](#). In: *Phys. Rev. Lett.* 125.15 (2020), 151801. doi:10.1103/PhysRevLett.125.151801. arXiv:2002.12630 [hep-ph].
- \* B. C. Allanach, B. Gripaios, and J. Tooby-Smith. [Solving local anomaly equations in gauge-rank extensions of the Standard Model](#). In: *Phys. Rev. D* 101.7 (2020), 075015. doi:10.1103/PhysRevD.101.075015. arXiv:1912.10022 [hep-th].
- \* B. C. Allanach, B. Gripaios, and J. Tooby-Smith. [Geometric General Solution to the  \$U\(1\)\$  Anomaly Equations](#). In: *JHEP* 05 (2020), 065. doi:10.1007/JHEP05(2020)065. arXiv:1912.04804 [hep-th].
- \* J. Davighi, B. Gripaios, and J. Tooby-Smith. [Quantum mechanics in magnetic backgrounds with manifest symmetry and locality](#). In: *J. Phys. A* 53.14 (2020), 145302. doi:10.1088/1751-8121/ab78ce. arXiv:1905.11999 [hep-th].

## Teaching

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2016	Undertook a teaching module as part of my undergraduate
2018	Demonstrator for theoretical physics part I (Department of Physics, Cambridge)
2019-2020	Supervisor for Gauge Field Theory (Department of Physics, Cambridge)
2019	Supervisor for Quantum Field Theory (DAMTP, Cambridge)
2020	Supervisor for Symmetries, Fields and Particles (DAMTP, Cambridge)

## Outreach

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2016-2018	Oxford Hands on Science roadshows, and committee member (2017)
2017-2018	Oxford Physics department and Christ church college open days
2017	Volunteered at Stargazing Oxford event
2019	Volunteered at Cambridge Science Festival
2019	Helped at Cambridge HEP master classes
2022	Helped at outreach events for Cornell's Centre for Materials Research

## Talks

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2020	Cambridge University: "Local anomalies in $Z'$ models"
2020	Edinburgh University: "Local anomalies in $Z'$ models"
2020	Bonn University: "Supersoft Stops"
2020	Perimeter: "A voyage through undulating dark matter and the GUTs of $su(48)$ "
2021	Cornell University: 'Inverse Higgs Constraints'
2022	NYU: 'A study of GUTs'
2022	Chicago: 'Symmetries of field theories'
2023	Carleton: 'Gauge extensions of the Standard Model'
2023	Cornell University: 'Symmetries of field theories'
2024	Cornell University: HepLean: Digitalising high energy physics
2024	Reykjavik University: Lean and the physical sciences

## Conferences

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2018	British Universities Summer School in Theoretical Elementary Particle Physics
2018	Annual Theory Meeting
2018	YTF 11
2019	Young Experimentalists & Theorists Institute
2019	NExT PhD Workshop
2019	Cavendish Laboratory Graduate Student Conference (was on the Organising committee and a convener)
2022	Phenomenology 2022 Symposium: From Virtual to Real
2022	Program on New Directions in Particle Physics
2022	Generalized Global Symmetries, Quantum Field Theory, and Geometry
2023	Cornell Topology Festival

- 2023 Higher Structures in Functorial Field Theory
- 2023 Categorical Symmetries in Quantum Field Theory (Workshop)

## Athletic achievements

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Personal Bests: 1:59.4 (800m), 3:59.40 (1500m), 8:39.6 (3000m), 9:59.49 (3000m Steeple chase), 15:08.92 (5000m), 30:01 (10k).