Dr. Alexander J. Hackett

PERSONAL DETAILS

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ACADEMIC POSITIONS

Postdoctoral Research Scientist 2023-
Institute of Physics of the Czech Academy of Sciences
Project Title: Stellar Evolution and Asteroseismology for constraining fundamental physics

ACADEMIC QUALIFICATIONS

Ph.D. Astronomy 2019-2023
Institute of Astronomy, University of Cambridge, UK
Supervisors: Professor Christopher A. Tout, Dr. Anna N. Żytkow
Thesis Title: Exotic Stars and Thorne-Żytkow Objects

B.A. Mod. (Hons) Physics and Astrophysics 2015-2019
Trinity College Dublin, Ireland
Final Degree Classification: I, TCD Gold Medal Awarded
Supervisor: Professor José H. Groh
Dissertation Title: The effects of convective overshooting on the evolution of the first stars

TEACHING EXPERIENCE

Part II Supervisor University of Cambridge, Natural Sciences Tripos
Astrophysical Fluid Dynamics
2019-2020

Part II Supervisor University of Cambridge, Natural Sciences Tripos
Structure and Evolution of Stars (Part II)
2019-2022

Part III(MASt) Examples Class Lecturer University of Cambridge, DAMTP
The Structure and Evolution of Stars
2020-2023

Part III(MASt) Examples Class Lecturer University of Cambridge, DAMTP
Binary Stars
2019-2022

PROGRAMMING LANGUAGES

Fortran
Proficiency in fixed-form and modern (free-form) syntax. Worked on projects / stellar evolution codes in modern (f90) and older (f77) formats. Experience in using modern standards, OOP-functional based approach, and familiar with older common constructions typical of legacy codes as well as modern modular paradigm. Experience with thread safe projects and usual compiler considerations.

C++
Proficient in C++ and C in multithreaded and CUDA environments – primarily in the context of the rapid binary population synthesis code binary_c. Worked on testing and development of binary_c and binary_c-python with Robert Izzard's research group at the University of Surrey.

Python
Experience in lightweight numerical computing, data handling, analysis and visualisation. Familiar with common mathematical, scientific and visualisation packages, such as `numpy`, `scipy`, `astropy`, `pandas`, etc.
Experience in applying deep learning as a means of data reduction and performing analysis on high-dimensional datasets (observable stellar variables, nuclear reaction network codes) – primarily using PyTorch to build classifiers and CNNs.

IDL

Made use of IDL for data handling and visualisation on a project involving the Geneva stellar evolution code, as well as for general array based data processing.

Perl

Familiarity with Perl for general programming purposes, involved with developing an API for linking the Cambridge STARS stellar evolution code to the Window to the Stars (WTTS) pedagogical tool, in order to migrate from using EV/EV TWIN as an underlying evolution code for the graphical interface.

Scripting languages

General purpose scripting in bash, zsh, tcsh, (c)lisp, python, perl, JS & TS and other common scripting languages, appropriate to purpose. Scripting for basic model grid setups, batch-job processing for cluster based computing with Slurm+Kubernetes, constructing graphical I/O tools, primarily for personal use with research-grade stellar evolution tools.

SOFTWARE DEVELOPMENT

MESA: Modules for Experiments in Stellar Astrophysics

The code for Modular Experiments in Stellar Astrophysics (MESA) is a modern, modular high performance stellar evolution code, written in f90, and very widely used in the stellar physics community. I have used MESA extensively for the purposes of modelling TŻO envelopes, and have written and used a wide range of modifying *hooks* into the code in the manner generally recommended by the code development community. I am also experienced in handling and visualising the data output from the code.

STARS: The Cambridge Stellar Evolution Code

STARS is a flexible, multi-use and heavily optimized stellar evolution code, written in Fortran 77, with original development dating back to the 1970s. Hence, STARS is a mature piece of software, with a great deal of development history and many publications produced with its assistance. STARS is a fully implicit Henyey code with an adaptive, non-Lagrangian computational mesh. Structure and (major) compositional variables are solved for simultaneously, with an expanded post-processing network of minor isotopes for, e.g. the study of TP-AGB stars.
I have used and modified this code extensively, adding new physics for the purposes of modelling Thorne-Żytkow Objects, magnetized white dwarfs and other star-like objects, altering the equation of state, equation setup and solving routines, as well as rewriting the input/output driver routines to utilise modern Fortran inlists for model settings, a Python routine for a handling model output as well as real-time and post-processing visualisations.

GENEC: The Geneva Stellar Evolution Code

The GENEC code is a widely used stellar evolution code in the field of massive star evolution, and is widely used specifically to make models of high mass stars across a wide range of metallicities and rotation rates.
I made use and extended the capabilities of the GENEC code to investigate the effects of convective overshooting, specifically the choice of overshooting prescription and scaling values thereof, on the evolution of massive Population III stars. The produced grid of models was then used to investigate effects of overshooting on the production of ionising photons during the main sequence evolution of these stars, in order to study the impact that these stars may have had on reionization.

LEADERSHIP AND OUTREACH

Individual Mentoring

Mentored students one-on-one on course material, in particular, for Cambridge Part III (Masters) courses on Stellar Evolution. Was put into contact with students needing additional mentorship prior to examinations via lecturers and college tutors/supervisors. Some mentoring conducted remotely on-line.

Cambridge University Guild of Change Ringers

Elected Steeplekeeper of the Cambridge University Bell Ringing Guild, with responsibility for maintenance and management of the tower at StAG: the University Church. Arranged for the complete replacement of the clapper of a bell, liaising with the Taylor's Foundry in Loughborough, UK in order to source an original, period appropriate wrought iron clapper.

Trinity College Space Society

Elected Secretary of the Trinity College Space Society, took meetings for weekly committee meetings, organized regular rocket launch outings including ticketing, insurance, location scouting, police paperwork for possession and use of explosive rocket motors and arranged transport to and from launch site.

Public Outreach

Heavily involved in public science outreach. Gave regular talks and guided telescope tours at Cambridge Institute of Astronomy public Wednesday open nights. Gave talks and demonstrations for the Researchers' Night of the Czech Academy of Sciences. Gave talks and engaged with the public directly at Veletrh Vědy, the largest annual science fair in the Czech Republic. Gave an invited talk on the history and future of human spaceflight at the 2022 International Astronautical Congress in Paris, as a guest of Buble Studios, a Hawai'i based creative agency for the space sector.

PUBLICATIONS

1. Murphy L. J. **et al**, 2021, *Ionizing photon production of Population III stars: effects of rotation, convection, and initial mass function*, MNRAS, 506, 4
2. Bhattacharya M., **Hackett A. J.**, Gupta A. Tout C. A., 2022, *Evolution of Highly Magnetic White Dwarfs by Field Decay and Cooling: Theory and Simulations*, ApJ, 925, 2
3. **Hackett A. J.**, Żytkow A. N., Tout C. A., 2024 (in press), *Modern Envelope Models of Thorne-Żytkow Objects*
4. **Hackett A. J.**, Bhattacharya M., Mukhopadhyay B., 2024 (in press), *Simulating the Structure and Cooling of Highly Magnetised Super-Chandrasekhar Mass White Dwarfs with* STARS
5. **Hackett A. J.**, Saltas I. D., 2025 (in prep), *Constraining fundamental physics with asteroseismology of low-mass stars: the fine-structure constant*

CONFERENCE CONTRIBUTIONS AND OTHER TALKS

Invited Talks:

1. **Hackett A. J.**, *Exotic Stars Across the HR Diagram*, Invited Seminar, School of Maths and Physics of the University of Surrey, December 2024
2. **Hackett A. J.**, *Exotic Stars*, Invited Seminar, TOS Special Group Meeting, HITS, Heidelberg, November 2024

Contributed Talks:

1. **Hackett A. J.**, *A new structure for TŻOs and implications for GCE: Disagreements in the new generation of models*, BridgeCE Annual Meeting, July 2024
2. **Hackett A. J.**, *Asteroseismic models of low mass stars for constraining fundamental physics*, European Astronomical Society Annual Meeting, July 2024
3. **Hackett A. J.**, *Super-Chandrasekhar mass, highly magnetic WDs as progenitors of over-luminous Ia SNe*, European Astronomical Society Annual Meeting, July 2024
4. **Hackett A. J.**, *Thorne-Żytkow Objects*, Stars 2020, August 2022
5. **Hackett A. J.**, *Thorne-Żytkow Object Envelope Models: A New Equilibrium Structure for Hybrid Stars?*, BridgeCE Annual Meeting, December 2022

Conference Proceedings:

1. Zuraiq Z., Kumar A., **Hackett A. J.**, Bhattarai S., Tout C. A., Mukhopadhyay B., *Simulating super-Chandrasekhar white dwarfs*, The Relativistic Universe: From Classical to Quantum, Proceedings of the International Symposium on Recent Developments in Relativistic Astrophysics, Springer Nature, November 2024
2. Zuraiq Z., Mukhopadhyay B., Kumar A., Bhattarai S., **Hackett A. J.**, Sakar A., Tout C. A., *Simulating super-Chandrasekhar white dwarf from main sequence star: Exploring stellar evolution codes STARS and MESA*, 42nd meeting of the Astronomical Society of India, January 2024
3. Mukhopadhyay B., Bhattacharya M., **Hackett A. J.**, Kalita S. Karinkuzhi D., Tout C. A., *Highly magnetized white dwarfs: implications and current status*, 16th Marcel Grossmann Meeting, July 2021

Posters:

1. **Hackett A. J.**, Tout, C. A., Żytkow, A. N., *TŻO Envelope Models: A new structure for hybrid stars and implications for GCE*, European Astronomical Society Annual Meeting, July 2024
2. **Hackett A. J.**, Tout, C. A., Żytkow, A. N., *Thorne-Żytkow Envelope Models: A New Equilibrium Structure for Hybrid Stars?*, European Astronomical Society Annual Meeting, July 2023
3. **Hackett A. J.**, Tout, C. A., Żytkow, A. N., *A Possible Path to Obtain Self-Consistent Models of Thorne-Żytkow-like Objects*, XXXIst IAU General Assembly, August 2022

REFERENCES

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