Naomi McWilliam

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RESEARCH INTERESTS

Exoplanets, Stellar Evolution, Machine Learning, Massive Gravity

EDUCATION

Imperial College London, London, United Kingdom — October 2020 — June 2024
Working towards Master of Science in Physics with Theoretical Physics — On track for First Class Honours
Working towards Thesis: 'Black Holes in Massive Gravity' — Cumulative GPA: 4.00/4.00

ACADEMIC EXPERIENCE

Massachusetts Institute of Technology — Massachusetts, US
Undergraduate Researcher — July 2023 — Present

- Developed a Neural Network that takes several stellar activity indicators as inputs (total solar irradiance, cross-correlation functions, unsigned magnetic flux etc.) and predicts the radial velocity (RV) of the Sun.
- Implemented the Neural Network using TensorFlow in Python. Performed pre-processing of input data. Used thorough methods to optimise the Neural Network and evaluate its performance.
- Extended on work by de Beurs, Zoe. L. et al. (Aug. 2022). "Identifying Exoplanets with Deep Learning. IV. Re-moving Stellar Activity Signals from Radial Velocity Measurements Using Neural Networks". In: 164.2, 49, p. 49.
- Reduced RV scatter from 154.7 $\mathrm{cm\,s^{-1}}$ to 92.1 $\mathrm{cm\,s^{-1}}$. This is a step to reducing RV precision down to 10 $\mathrm{cm\,s^{-1}}$ to detect exoplanets.
- Submitted to Monthly Notices of the Royal Astronomical Society.
- Presented two talks on my methods, the impacts of my findings, and the goals we are working towards for extreme precision radial velocity measurements.

Imperial College London — London, UK
Master's Thesis — July 2023 — Present

- Working with Professor Claudia de Rham on 'Black Holes in Massive Gravity'. Massive Gravity is a variation on General Relativity, with the graviton being massive.
- Produced a literature review on General Relativity after independently studying the contents of Carroll, Sean M. (Dec. 1997). *Lecture Notes on General Relativity.*
- Analytically derived and worked through equations discussed in de Rham, Claudia (Dec. 2014). *Massive Gravity.* In: Living Reviews in Relativity.
- Working towards Black Hole solutions in Massive Gravity through taking approximations and deriving the physical constraints. Will extend on the analyis performed in Rosen, Rachel A. (Oct. 2017). "Non-singular black holes in massive gravity: time-dependent solutions". In: Journal of High Energy Physics 2017.10, 206, p. 206.
- Studied theories of pulsars in Massive Gravity.

Zoological Society of London — London, UK
Summer Research Intern — June 2021 — September 2021

- Developed code to assist with the analysis of camera trap data. This data can be used to help with conservation efforts and biodiversity research. Supervised by Dr Marcus Rowcliffe
- Created a GUI to increase the usability of programs dedicated to analysing camera trap data using deep learning techniques. I worked in Python and Windows command prompt. This is available through my GitHub.
- Wrote code using OpenCV in python for image analysis studies, specifically using background subtraction methods to help identify animals in camera trap images.
- Created an interactive map using the Python package 'Leaflet', that explores the different species present in the Gobi desert.
- Establishing the efficiency and accuracy of current camera trap analysis programs by searching through metadata and creating a confusion matrix in R.
- Conducted image and data analysis on camera trap images in R.

PUBLICATIONS

First Author
Submitted to Monthly Notices of the Royal Astronomical Society
McWilliam, N., de Beurs, Z.L., Vanderburg, A., et.al. "Identifying Exoplanets with Deep Learning VI. Enhancing neural network mitigation of stellar activity RV signals with additional metrics" In: Submitted to MNRAS.

PROJECTS

Team Based LHCb Data Analysis Imperial College London
Machine Learning Subgroup Leader October 2022 — December 2022

- Determined parameters of the $B^0 \to K^{*0}\mu^+\mu^-$ decay using particle data from CERN in a group of 25, utilising GitHub for collaboration.
- Applied Neural Networks and Boosted Decision Trees, feature selection, and hyperparameter tuning in Python to remove background decays from a large number of datasets.
- Created an advanced animated presentation receiving high praise from staff and group members.
- Achieved an individual grade of 85% (Converts to 4.3/4.3 GPA)

Neutrino Oscillations Imperial College London
Computational Physics Project December 2022

- Implemented a minimisation algorithm in Python to determine neutrino oscillation parameters from a data set, by minimising a log-likelihood function.
- Coded a Quasi-Newton algorithm, and a Monte Carlo minimisation (Simulated Annealing) algorithm.

Thermodynamics Simulation Imperial College London
Second Year Coding Project December 2021

- Developed a particle simulation in Python to investigate various thermodynamic properties.
- Implemented physics principles and equations (including using NumPy and SciPy packages), learned in 'Thermodynamics and Structure of Matter' module, to the simulation.

Speaking with Instruments Imperial College London
First Year Summer Project April 2021 — July 2021

- Developed a sound analysis program in a group of four using Python, which takes an audio input and outputs the audio as a 'speaking piano'. Achieved a mark of over 90% (4.3/4.3 GPA), one of the top projects.
- Applied FFTs and used optimisation algorithm to best match the given audio file in the time domain, by using the 88 piano notes as base functions.
- Responsible for producing an accompanying presentation to describe the projects process and results. Received very positive feedback highlighting excellent coding, teamwork, and explaining.

Atmospheric Air Quality Studies National Physical Laboratory
Laboratory Work Experience July 2019

- Performed experiments in a laboratory using an FTIR to identify different atmospheric gases, to study the environmental impacts of emissions from industrial companies.
- Chose project due to similar applications in identifying elements in stars.
- Learned and tested different experimental techniques to reduce noise such as using liquid nitrogen.
- Analysed spectral data collected on air quality using MATLAB to identify different elements present in the data.
- Presented my results to a large audience to conclude my research.

AWARDS

Dean's List Imperial College London
Awarded to the top 10% of the cohort. I was ranked 5th in the cohort out of 267 students during my second year. 2022

Second Prize for Winton GCSE Poster Competition The Royal Astronomical Society
Presented the poster 'How Strange are Neutron Stars?' 2019

Recognition of Academic Achievement The Royal Astronomical Society
I was awarded a recognition of academic achievement by The Royal Astronomical Society for my 'Outstanding performance in the 2019 GCSE Astronomy exam'. 2019

Distinction - British Mathematical Olympiad for Girls 2019, UK
Merit - British Mathematical Olympiad Round One 2020, UK
Merit - British Physics Olympiad A2 Challenge 2019, UK
Silver - Senior Mathematical Challenge 2019, UK
Bronze II - British Physics Olympiad Round One 2020, UK

PRESENTATIONS

Mitigating RV Jitter for Sun-like Stars using Neural Networks — Massachusetts Institute of Technology
Summer MKI Undergraduate Research Forum (SMURF) — August 2023

Mitigating RV Jitter for Sun-like Stars using Neural Networks — HARPS-N Solar Telescope Collaborators
HARPS-N Solar Telescope Strategy Meeting. Hosted by David Latham. — November 2023

The Search for New Physics in the B^0 Decay — Imperial College London
Presented to conclude Team Based LHCb Data Analysis Project. Discussed machine learning methods used and implications of results. — December 2022

Speaking with Instruments — Imperial College London
Video presentation to summarise methodology and results of First Year Project. — June 2021

Infrared Spectroscopy — National Physical Laboratory
Presentation to researchers, supervisors, and peers on the research I conducted during my 'Atmospheric Air Quality Studies' project. — July 2019

TEACHING EXPERIENCES

Kumon — Watford, UK
Tutor — September 2018 — September 2019

- Main tutor at my local Kumon center teaching Maths and English.
- Taught children from the age of 3 to 16.
- Guided them through questions they were struggling with. Taught the older students new concepts that had not yet been encountered in classes.

First year computing demonstrator — Imperial College London
Tutor — October 2023 — November 2023

- Demonstrator for Python classes for students in first year Physics. These were 3 hours long with around 60 students.
- Helped them to problem-solve their physics related coding tasks, encouraged them to discuss their results with myself and their peers, and assisted in debugging their code.
- Focused on students with no prior coding experience
- Encouraged many girls, as we are a minority in the cohort, to join the women in Physics society and women in Machine learning classes.

Mechanics and Relativity module shaper — Imperial College London
Tutorial Assistant — July 2022 — September 2022

- Assisted the department in upgrading tutorial sheets for for the undergraduate Mechanics and Relativity module, PHYS40002, by incorportating them onto an online platform being developed called 'Lambda Feedback'.
- Explained the solutions to tutorial problems step-by-step in great detail to further students understanding of the subject. This recieved high praise from students and lecturers.
- Wrote code in Python for evaluating two expressions to see if they were mathematically equivalent. Frequently performed tests on the software.

Astronomy Teacher — Watford Grammar School for Girls
Astronomy Club Leader — September 2019 — March 2020

- Teacher of the school's Astronomy club, where I taught a class of around 30 for an hour once a week
- Made presentations, worksheets, and homework in preparation for their Astronomy GCSE exam.
- Presented weekly Astronomy news to encourage them to pursue this field.

Private Tutor — Watford Grammar School for Girls
Physics and Maths teaching — January 2021 — September 2022

- Tutored two A-Level students (ages 18-19) in Maths, Further Maths, and Physics A-Level.
- Guided them through problems and helped to explore their passion for Physics.
- Both achieved the highest grade, A*, in all subjects and went on to study Physics at University.