

# Ra'ad Costello-Mahmoud

## PhD MPhys

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### Career Summary

Machine learning engineer with 4 yrs industry experience and a doctorate in computational astrophysics. I have worked on several ML projects from data synthesis to model construction and deployment. As an experienced Python developer of over a decade, I have a track record of valuable software contributions in a range of sectors, from producing cutting-edge time-series models of black holes, to novel computer vision techniques now employed at a major automotive manufacturer, to detection of explosives in X-ray images for aviation security.

In my current role I lead the development of neural networks for the characterisation of pathogenic genomic material to combat bio-terrorism, funded by a key UK Governmental body. As part of this work, I am an invited member on a NATO Sensors & Electronics Technology Panel (HFM-328).

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### Software Development Skills

#### Programming Languages.

- Python** Native language. 11 years experience on projects including physical modelling of magnetic dipoles, cosmic expansion, black hole accretion dynamics, and extensive ML. Proficient with many Python libraries, including SciPy, NumPy, matplotlib, scikit-learn, OpenCV, PIL, pandas, SQLite, fastAPI, wandb, PyTorch and TensorFlow (see "Deep Learning & MLOPs").
- Bash** Working proficiency. 10 years of working with Linux - primarily in Ubuntu - has led to good knowledge of shell scripting. I am comfortable with package/environment management tools such as conda, pip and venv.
- SQL** Working proficiency. 4 years experience. Familiar with a range of integrations including Python SQLite, postgres, PGAdmin, with experience integrating into live service systems.
- C++** Moderate proficiency. 1 year experience, producing fast subroutines to model the energy and time-dependent behaviour of accretion physics. This fast code allowed direct model fitting of observational high-energy data for the first time, overcoming decades-long standing challenges for the field.

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## Deep Learning & MLOps.

- Tensorflow 5.5 years experience (1.5 yrs research + 4 yrs industry) building DL algorithms for inference in astronomy, the automotive industry, aviation security and bioinformatics.
- Keras
- PyTorch I have a good understanding of the mathematical basis underlying many types of neural networks - in particular convolutional networks and the object detection family - and how to construct customised networks, loss functions and robust data-sets using OOP.
- Local LLMs 0.5 years experience, constructing, deploying and maintaining a corporate assistant service for in-house use based on Ollama + Llama-3
- Data Production At Kromek I am responsible for data generation pipelines for object detection (explosive ID), and for sequence characterisation (genomic analysis). This has involved designing and writing pipelines which can generate simulated data from scratch, permit custom augmentations, record parameters of the dataset, and ensure complete reproducibility of large datasets (~ 100s of GBs). I have experience in manual and automated annotation of data, having built tools for my team to web-scrape virology literature, and curate/clean the resultant labels.
- Cloud Computing & Restful APIs Extensive experience with AWS (mainly EC2) for data generation, model development and deployment, building micro-service based architectures for a growing professional user-base. These micro-services have mainly employed fastAPI as their web framework.
- CI/CD Fluent in in app containerisation with Docker and deployment via uvicorn, DockerHub, GitHub actions to AWS EC2.
- VCS Git & GitHub: 7 years of programming collaboratively has necessitated good Git habits. See contribution history at [GitHub](#).

## Other Technical.

- HPC 3 years experience writing Python/C++ code for usage on high performance computing on COSMA5, a 6700-core Sandy Bridge system.

## Interpersonal Skills.

Extensive experience of presenting my work, having spoken at several international conferences in astrophysics and bioinformatics.

Well suited to output-oriented teamwork and collaboration, evidenced by past internships and prolific collaborations during PhD.

Good experience of mentoring in an industrial context at Kromek, where I have overseen and directed the technical work of a PhD intern and junior colleagues.

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## Employment + Experience

2020–Present **Kromek Group Ltd., Sedgefield, UK.**

- **Deep Learning Engineer** (3 years 8 months)
  - Currently the technical lead of a small team of engineers developing neural networks to characterise short DNA and RNA reads.
  - Project funded by a key UK Government defence body, following on from a successful 24-month project which I also lead.
  - Solely engineered a set of proprietary neural nets which integrate computer vision and materials analysis for explosive detection in aviation security. These networks augment existing object-detection architectures with 3D and materials information to drastically improve threat detection rates for X-ray imaging.
- **Image Processing Engineer** (7 months)
  - Developed and optimized image processing algorithms.
  - Implemented real-time image analysis systems.
  - Worked closely with software engineers to deploy solutions.

2019–2019 **Nissan Motor Manufacturing UK Ltd, Sunderland, UK.**

- **AI Intern** (2 months)
  - Industrial placement in the Deep Learning team during my PhD.
  - Developed methods for improved computer vision techniques.
  - Heavy focus on convolutional neural network (CNN) construction and optimisation, and image processing techniques. Image optimization method I designed now plays a part in their automated defect detection system, with this system deployed at multiple manufacturing sites world-wide.

2017–2017 **Japan Aerospace Exploration Agency (JAXA), Tokyo, Japan.**

- **Astrophysics Researcher** (3 months)
  - Collaborated with international team on black hole accretion physics research.
  - Provided Python-based detector calibration code now employed for interpretation of space-based detector data.

2015–2015 **Durham University Superconductivity Group, Durham, UK.**

- **Intern** (3 months)
  - Conducted research into the mechanical properties of superconducting solder alloys for use in the next generation of fusion tokamaks to follow the \$14 billion ITER (International Thermonuclear Experimental Reactor) in Cadarache, France.

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## Education

2016–2020 **PhD in Computational Astrophysics, Centre for Extragalactic Astronomy, Durham University, Durham, UK.**

- Thesis title: ***Spectral-Timing Models of the Central Engine in Accreting Black Holes***
  - Fully funded by STFC over 3.5 years.
- Awards:
  - Elsevier book prize for outstanding 1st year postgraduate student [pool of 30; £100].

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- 2012–2016 **MPhys in Physics and Astronomy**, *Department of Physics, Durham University, Durham, UK.*
- 1st Class, highest degree mark in year
  - Dissertation title: ***A Monte Carlo Approach to Modeling Habitability in the Milky Way***
  - Awards:
    - 2014 Vice-Chancellor's academic excellence award [£2000].
    - 2015 Computational physics prize [pool of 200; £100].
    - 2016 JA Chalmers prize for highest overall degree mark (83%) [pool of 200; £100].
- 2012–2016 **A-Levels**, *Monks Walk Comprehensive School, Welwyn Garden City, UK.*
- 'A2': Mathematics (A\*)
  - 'A2': Physics (A)
  - 'A2': Chemistry (A)
  - 'AS': Further Mathematics (A)

## Publications

**"Origins of the UV/X-ray Relation in Arakelian 120"**, *R. Mahmoud, C. Done, D. Porquet, A. Lobban, 2023, MNRAS, 521(3), 3586.*

**"Discarding the disc in a changing state AGN: the UV/X-ray relation in NGC 4151"**, *R. Mahmoud, C. Done, 2020, MNRAS, 491(4), 5126.*

**"Reverberation Reveals the Truncated Disc in the Hard State of GX 339-4"**, *R. Mahmoud, C. Done, B. De Marco, 2019, MNRAS, 486(2), 2137.*

**"A Physical Model for the Spectral-Timing Properties of Black Holes"**, *R. Mahmoud, C. Done, 2018, MNRAS, 480(3), 4040.*

**"Modelling the Energy Dependence of Black Hole Binaries"**, *R. Mahmoud, C. Done, 2018, MNRAS, 473(2), 11.*

**"Superconducting and Mechanical Properties of Low-Temperature Solders for Joints"**, *Y. Tsui, R. Mahmoud, E. Surrey and D. Hampshire, 2016, IEEE Trans. Appl. Supercond., 23 (3).*

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