Mateusz Kapusta

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https://github.com/Wesenheit
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EDUCATION

Master of Science, **2023-2026** *(expected)*
Master of Science in Astrophysics
Warsaw University Observatory, Faculty of Physics

Bachelor of Science, **2020-2023**
Inter-faculty Individual Studies in Mathematics and Natural Sciences, University of Warsaw, Poland
Grade: 4.96/5 (2-5 scale, 5 is highest), graduated with distinctions
Major: Astrophysics, Physics
Minor: Computer Science

EXPERIENCE

Machine Learning Intern, ASML (Veldhoven, Netherlands)   October 2025 – June 2026
Working in the R&D department on machine learning solutions for diagnosing degradation in NXE lithography machines (various contaminations in the optical column).

- Researched hybrid models integrating physical simulations with machine learning, focusing on data-driven corrections to the physical models.

- Implemented Bayesian inference algorithms to infer contamination profiles in the machines based on the hybrid models.

- Developed high-performance implementations of inference algorithms, optimized for both edge devices (ordinary laptops) and large-scale HPC clusters.

Quantitative Developer Intern, UBS AG   July 2025 – September 2025
Worked on a high-performance, multi-code C++ engine used to price loans within the Lombard Lending unit.

- Performed code benchmarking and bottleneck analysis to identify performance issues.

- Investigated parallel efficiency and load balancing using Intel TBB.

- Applied memory and computational optimizations, resulting in a codebase that was $3\times$ faster and $2\times$ more memory-efficient.

Student research assistant, Nicolaus Copernicus Astronomical Center   April 2023 - July 2025
Working under supervision of Krzysztof Nalewajko (NCAC). Project in cooperation with Bart Ripperda (CITA, Toronto) and Alexander Philippov (University of Maryland).

- Working with extreme resolution Magnetohydrodynamical (MHD) simulations created with H-AMR code.

- Studying stability of a astrophysical jets launched from black holes.

- Investigating influence of magnetic flux eruptions, associated with Magnetically Arrested Discs (MAD), on the properties of the jet.

- Presented work will be submitted as a second-author paper to Astrophysical Journal Letters.

Student research assistant at Astronomical Observatory November 2022 - July 2025
Student position in grant 2021/41/B/ST9/00252, working under the supervision of Przemysław Mróz.

- Performing MCMC modelling of microlensing events discovered as the part of 4th phase of the OGLE project.
- Investigating Free Floating Planet (FFP) microlensing event OGLE-2023-BLG-0524. Working on theoretical modelling, analysing legacy Hubble Space Telescope (HST) photometry, performing detectability simulations in order to verify FFP hypothesis.
- Research resulted in 4th-author publication in ApJS, and first-author publication in A&A about OGLE-2023-BLG-0524 event.

Bachelor's Thesis at Warsaw University Astronomical Observatory July 2022 - July 2023
Working under the supervision of dr Przemysław Mróz on the data analysis from the OGLE survey to search for Dormant Black Hole candidates.

- Analysing OGLE data using the method introduced in Gomel et al. 2021
- Designing Python based MCMC code to assemble spectral energy distribution (SED) for candidate objects.
- Inference of the parameters of binaries using the OGLE and Gaia DR3 data, searching for compact companion stars.
- Project resulted in first-author paper accepted in Acta Astronomica.

Intern at Nicolaus Copernicus Astronomical Center July 2022 - October 2022
Project: "Measuring the structure of relativistic jets in numerical simulation results" under the supervision of Krzysztof Nalewajko (NCAC) and prof. Agnieszka Janiuk (CFT PAN).

- Worked with results from HARM MHD code to study the structure of magnetically arrested discs.
- Developed a few Python routines to search for magnetic reconnection and other interesting magnetic phenomena.
- Work accomplished during the internship resulted in second-author publication submitted to Astronomy & Astrophysics.

Intern at Nicolaus Copernicus Astronomical Center July 2021 - October 2023
Project: "Energy of a Strange Quark Star" under the supervision of Fatemeh Kayanikhoo and dr M. Cemeljic

- Worked with LORENE library to study the structure of relativistic strange quark stars, ported part of functions to work with C++17 standard and MPI multithread environment.
- Developed Python code to calculate the external energy of a star contained in a magnetic field.
- Developed multi-threaded C++ code to calculate the equation of state of the magnetized strange matter.

PROJECTS **Neural Posterior Estimation for Spectral Energy Distribution fitting** Github

Reaserching applications of Neural Posterior Estimation in Astronomy. Spectral Energy Distribution fitting is powerfull yet computationally expensive technique widlely used in Astronomy. I demonstrated that with the help of normalizing flows one can speed up the inference of parameters by several orders of magnitudes. To do so, I designed my own complex preprocessing model that was paried with Masked Autoregressive Flow. Model was then fined-tuned so it can operate on real-life astronomical data. Model was accepted as poster at the ICML 2025 co-located workshop: Machine Learning for Astrophysics.

Computational Fluid Dynamics on GPU-s   Github

Astrophysical research heavily rellies on the simulations. In the project, a Riemann solver was implemented to solve the equations of relativistic fluids. It is written in CUDA-enabled Julia code paralellized with MPI to utilize massive GPU clusters. It relies on manually written computational kernels that are optimized for A100 NVIDIA GPU-s (compute - memory bandwidth - communication). Project is being developed with the help of EuroHPC development access computing grant EHPC-DEV-2025D02-085 on the Leonardo BOOSTER, where I am a Co-PI.

PUBLICATIONS

- **M. Kapusta**, P. Mroz, et al. "HST pre-imaging of a free-floating planet candidate microlensing event" Accepted in Astronomy & Astrophysics [`arXiv:2507.01109`]

- K. Nalewajko, **M. Kapusta**, A. Janiuk "Chaotic Magnetic Disconnections Trigger Flux Eruptions in Accretion Flows Channeled onto Magnetically Saturated Kerr Black Holes" Accepted in Astronomy & Astrophysics [`arXiv:2410.08280`]

- P.Mróz, A.Udalski, M.Szymański, **M. Kapusta**, et al. "Microlensing Optical Depth and Event Rate toward the Large Magellanic Cloud Based on 20 yr of OGLE Observations" Accepted in ApJS [`arXiv:2403.02398`]

- **M. Kapusta**, P. Mróz. "The search for Dormant Black Holes in the OGLE data" Accepted in Acta Astronomica [`arXiv:2401.11293`]

TALKS & POSTERS

- **M. Kapusta**: "IrisML: Neural Posterior Estimation for the Spectral Energy Distribution fitting" ICML 2025: Machine learning for Astrophysics workshop.

AWARDS & SCHOLARSHIPS

- Gold medal at 2021 University Physics Competition (as part of the team representing Faculty of Physics)

- Silver medal at 1st Global e-Competition on Astronomy and Astrophysics (in place of 14th International Olympiad on Astronomy and Astrophysics), 2020

- Bronze medal at 13th International Olympiad on Astronomy and Astrophysics, 2019 Hungary

- Winner of 62th and 63th Polish Astronomy Olympiad

- Finalist of 67th and 69th (11th place) Polish Physics Olympiad

- Finalist of 70th Polish Mathematical Olympiad

- Minister of Education's scholarship in the year 2018/2019, 2019/2020

- Rector scholarship in the academic year 2020/2021, 2021/2022, 2022/2023, 2023/2024

OUTREACH

- Judge at International Math Competition Naboj (March, 2023-2025)

- Judge at 16th International Olympiad on Astronomy and Astrophysics (August, 2023)

COMPUTER SKILLS

Languages & Software:
- Computer languages - Python,C/C++, Julia, R, Rust, Fortran

- Deep learning knowledge using PyTorch/JAX.

- Parallel programming using MPI/OMP.

- GPU programming skills using CUDA (also paired with MPI).

Language

- English - C1 (103 TOEFL)
- Polish - native speaker
- German - A2/B1