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 the machine learning solutions for the diagnostic of the degradation of NXE litographic machines (various contaminations in the optical column).

- Researching hybrid models integrating physical simulations with the machine learning models. Most of the work was centered around developing data-driven corrections to the physical model used in the diagnostic process.

- Based on the created model, implementing Bayesian inference algorithms to infer the contamination profile in the machine.

- High performance implementation of the inference algorithms including optimization for edge devices like oridnary laptops and large-scale HPC clusters.

Quantitative Developer intern, UBS AG July 2025 - September 2025
Working on the high-performant, mulit-code C++ engine used to price loans within Lombard Lending unit.

- Code benchmarking, bottleneck identification.

- Investigation of parallel efficiency of the code, load balancing of the code using IntelTBB.

- Memory and other optimizations.

- In the end, code after optimization 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 widelly 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