

Mateusz Kapusta

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Github: <https://github.com/Wesenheit>

PROFILE

I am a Master's student currently studying at the Faculty of Physics, University of Warsaw. I completed my Bachelor's thesis under supervision of Przemysław Mróz at the Warsaw University Observatory. I graduated from the collage of Inter-Faculty Individual Studies, where I had an opportunity to take different courses including specialized lectures for Mathematics and Computer Science majors. During my studies I had an opportunity to work on different aspects of Astrophysics, ranging from observational projects to theoretical ones. Currently I work with Krzysztof Nalewajko (Nicolaus Copernicus Astronomical Center - NCAC), investigating astrophysical jets launched from Supermassive Black Holes with the help of numerical simulations. In free time I like to explore Machine Learning based methods applied in the field of Natural Sciences, solving problems across different domains from Bioinformatics to Astronomy.



EDUCATION

Master of Science, 2023-2025 (expected)

Master of Science in Astronomy
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: Astronomy, Physics
Minor: Mathematics, Computer Science

High School, 2017-2020

IIIrd Secondary School, Wroclaw, Poland
grade: 5.00 (1-6) scale
graduated with distinctions

EXPERIENCE

Student research assistant, Nicolaus Copernicus Astronomical Center April 2023 - present
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 astrophysical jets launched from black holes.

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

Student research assistant at Astronomical Observatory November 2022 - present
 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, currently preparing first author publication 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 (in revision).

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.

PUBLICATIONS

- 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](https://arxiv.org/abs/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]
- F. Kayanikhoo, **M. Kapusta**, M. Cemeljic."The maximum mass and deformation of rotating strange quark stars with strong magnetic fields" Submitted to Physical Review D [arXiv:2305.03055]

TALKS & POSTERS

- **M. Kapusta** "Extreme resolution GRMHD simulations of Astrophysical jets", presentation at 10th Symposium for Young Researchers, presentation awarded with distinctions (September 2024, Warsaw)
- **M. Kapusta** "Iris-ML: Neural Density Estimation for the Spectral Energy Distribution fitting." poster at GHOST 2024 Machine learning conference (April 2024, Poznan).
- K. Nalewajko, **M. Kapusta**, A. Janiuk. "Initialization of magnetic flux eruptions at accreting black holes" European Astronomical Society meeting 2023 (poster)
- F. Kayanikhoo, **M. Kapusta**, M. Cemeljic. "The maximum gravitational mass and deformation of magnetized rotating strange quark stars" European Astronomical Society meeting 2023 (poster)

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, 2024)
- Judge at 16th International Olympiad on Astronomy and Astrophysics (August, 2023)
- Judge at International Math Competition Naboj (March, 2023)

COMPUTER SKILLS

Languages & Software:

- Computer languages:
- Python - advanced
 - C/C++ - advanced
 - Julia - advanced
 - R - intermediate
 - Fortran - intermediate

- Rust - intermediate

Additional computer-related skills:

- Bayesian modeling using emcee, Pyro, NumPyro, PyMC, and Tensorflow Probability
- 3D visualizations with Paraview and Mayavi
- Parallel programming using MPI/OMP
- Low-level programming using Python C API
- Deep learning experience using PyTorch, Tensorflow, Jax
- Grain level parallelism using SIMD
- Experience with astronomical Python libraries like Astropy, Astroquery, PyVO

Operating Systems: Advanced knowledge of Linux OS

Language

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