

# Aliaksandr (Alex) Melnichenka

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## ACADEMIC FOCUS

Computational physics with emphasis on plasma turbulence and radio polarimetry, self-interacting dark matter near supermassive black holes, and nonequilibrium transport in Dirac electron fluids.

## EDUCATION

### Berea College

May 2027

B.S. in Physics & Mathematics (double major); minor in Computer Science; Dean's List each term to date Berea, KY

### Lyceum of Belarusian State University (STEM magnet high school)

2022–2024

STEM magnet program, physics track; admission by national exam

Minsk, Belarus

## RESEARCH EXPERIENCE

### Electron-Fluid Instabilities in Dirac Materials (with L. Levitov)

MIT Condensed Matter Theory

#### Undergraduate Researcher (first author)

2025 – present

- First author on a manuscript under review at *Physical Review Letters* (arXiv:2512.16571) establishing self-oscillatory transport and running density waves in graphene electron fluids.
- Built and validated the numerical pipeline; mapped instability threshold and wavelength selection; computed collision-operator eigenmodes on large grids to update key modeling assumptions.
- Designed an experimental device geometry and measurement protocol to enable direct tests.

### Faraday Screen Method for Turbulence Recovery (with A. Lazarian & D. Pogosyan)

UW–Madison

#### Undergraduate Researcher

2025 – present

- First author on a manuscript submitted to *The Astrophysical Journal*: single-frequency polarization diagnostic to recover inertial-range magnetic turbulence statistics from one map.
- Validated on synthetic Faraday screens and Athena MHD turbulence simulations across sub-Alfvénic and super-Alfvénic regimes; built a reproducible pipeline with checks for interferometric filtering.
- Practical for LOFAR, MeerKAT, and VLA archives. Talk slides

### Self-Interacting Dark Matter near SMBHs (with M. Vogelsberger)

MIT Kavli Institute

#### Undergraduate Researcher (mentor: Xuejian “Jacob” Shen)

2025 – present

- Reproduced published benchmarks for self-interacting dark matter evolution near supermassive black holes; isolated discrepancies to normalization and unit mappings using targeted ablation tests.
- Developing an orbit-averaged evolution model with stochastic loss-cone capture; deriving scaling predictions for collapse and seed timescales. Notes

## PUBLICATIONS & PREPRINTS

- [1] **A. Melnichenka\***, P. Liong\*, A. Bukhtayi, A. Bilous, L. Levitov. “Spontaneous Running Waves and Self-Oscillatory Transport in Dirac Fluids.” *under review at Physical Review Letters; arXiv:2512.16571 [cond-mat.mes-hall]*, 2025. These authors contributed equally.
- [2] **A. Melnichenka**, A. Lazarian, D. Pogosyan. “Recovering 3D Magnetic Turbulence from a Single Polarization Map.” *submitted to The Astrophysical Journal*, 2026.
- [3] **A. Melnichenka**, X. Shen, V. Tran, M. Vogelsberger. “Drift Diffusion Coefficients for Self-Interacting Dark Matter.” *in preparation*, 2026.

## SELECTED TALKS

Slides: PDF — Video: YouTube

### American Physical Society DPP 2025

Long Beach, CA

Contributed oral talk (12 min): “3D Magnetic Turbulence Recovery from Polarization Maps”

Nov 2025

### American Astronomical Society (AAS) 247

Phoenix, AZ

Oral talk: “Single-frequency Faraday-screen tomography: turbulence from one map”

Jan 2026

### The Magnetized Turbulent Universe (Honoring A. Lazarian)

Playa del Carmen, MX

Invited talk: *polarization-angle statistics and crossover scaling*

Nov 2025

## HONORS & AWARDS

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- Belarus National Physics Olympiad: **Gold** (2022), **Bronze** (2023), **Silver** (2024); Top-6 nationally (IPhO reserve training camp, 2022).
- Presidential Award for Gifted Youth (Belarus), 2022.
- Invited research speaker: *The Magnetized Turbulent Universe: A Conference Honoring Alex Lazarian*, Mexico (Nov 2025).

## LEADERSHIP & OUTREACH

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### SavchenkoSolutions

*Community-maintained archive for Savchenko's "Problems in Physics"*

Founder

2023 – present

- Founded and engineered a community-maintained platform for Savchenko's *Problems in Physics*; hosts 2,023 problems and 1,434 published solutions, with about 1,500 daily users across 40 countries.
- Designed editorial workflow: review queue, quality assurance, and version control; bilingual Russian and English standards for correctness and exposition.
- Personal output (astrosander): **12,820** total contributions, **847** solutions, **362** English translations. Profile

### BelSO.org

*Integrated science olympiad infrastructure for Belarus*

Founder and lead engineer

2023 – present

- Founded and engineered an integrated science olympiad platform (physics, mathematics, astronomy, informatics) with search, taxonomy, difficulty tagging, and contributor workflows.
- Hosts 8,500 problems and 3,200 solutions serving about 12,500 users; recognized on International Physics Olympiad country resource pages.

## SELECTED SOFTWARE & DATA ARTIFACTS

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- Open-source scientific software: **AstroTurbulence** (polarization statistics and figure regeneration), **electronic-kapitsa-waves** (spectral synthesis and structure functions), **SIDM\_Transport\_Theory\_vs\_MC** (drift diffusion derivations with Monte Carlo tests).
- Reproducible research practice: commit-pinned figures, environment specifications, minimal run scripts.
- GitHub: [github.com astrosander](https://github.com/astrosander)

## TEACHING & MENTORING

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### Berea College

*Teaching Assistant, Physics and Astronomy*

Berea, KY

Jan 2025 – present

- Led weekly office hours and targeted review sessions; supported labs and demonstrations; graded written work using transparent rubrics.
- Coached students on scientific writing and problem-solving clarity: assumptions, units, error checking, and reproducible workflows.

## SELECTED COURSEWORK

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- Real Analysis, Differential Equations, Numerical Analysis, Topology, Combinatorics, Classical Mechanics, Quantum Physics, Thermal Physics.

## SKILLS

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**Programming:** Python (NumPy, SciPy, Astropy, JAX), C, C plus plus, Bash, Git, L<sup>A</sup>T<sub>E</sub>X.

**Methods:** Turbulence statistics; polarization angle and structure correlations; Monte Carlo and Langevin methods; numerical ordinary and partial differential equations; spectral methods.

**Languages:** English (fluent), Belarusian (native), Russian (native).