Ilia **Kuk**

Ph.D. Candidate, Applied Mathematics · Graduate Researcher

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"Inverse scattering for forward progress."

Education

The University of Arizona — *Tucson, AZ, USA*

Ph.D. Applied Mathematics, advanced to candidacy (expected May 2027) — *Aug. 2022 – Present*

- Awarded a Grogan Scholarship

The University of Arizona — *Tucson, AZ, USA*

M.S. Applied Mathematics — *Aug. 2022 – May 2024*

Skoltech (Skolkovo Institute of Science and Technology) — *Moscow, Russia*

Ph.D. Physics (program started), transferred to The University of Arizona — *Sep. 2020 – Jul. 2022*

- Awarded an increased scholarship after Year 1 in recognition of publication merit

Ufa State Aviation Technical University (now Ufa University of Science and Technology) — *Ufa, Russia*

Specialist Diploma (integrated B.S./M.S.), Infocommunication Technologies and Special Communication Systems — *Sep. 2015 – Jun. 2020*

- Graduated with honors ("Red Diploma")
- Awarded Presidential Scholarship of the Russian Federation (2019–2020)
- Awarded merit-based increased scholarship (2017–2020, each year) for scientific achievements (publications, conferences, and patents)

Skills

Programming	Python, C/C++
OS	Linux, Windows
Tools	Git, Docker, MATLAB, Mathematica, LaTeX
Machine Learning	PyTorch, Deep Learning, Fourier Neural Operator, CNN, GAN, NLP
Scientific Computing	NumPy, SciPy, Numba
HPC & Parallel	MPI, OpenMP, CUDA kernels, Slurm
Data & Visualization	Matplotlib, Plotly, TikZ/Quantikz, Adobe Illustrator
Languages	Russian, English

Research

University of Arizona — *Tucson, AZ, USA*

Inverse Scattering and Optical Communications — *Aug. 2022 – Present*

- Developed an affine-map formulation of the inverse scattering transform (IST) for the NLSE; derived a low-rank approximation of the map (arXiv:2507.20470).

New Frontiers of Sound Science & Technology Center (University of Arizona) — *Tucson, AZ, USA*

Quantum-Inspired (Topological Acoustic) Computing — *Sep. 2023 – Present*

- Designed and experimentally validated acoustic analogs of Hadamard, CNOT, and T gates on a nonlinear metastructure; introduced a unified representation enabling multiple logical operations via distinct physical actions (JASA, 2025).
- Realized the period-finding core of Shor's algorithm using phase-bit (*phibit*) logic on a topological acoustics platform; manuscript in submission; invention disclosure planned.

Biosphere 2 (University of Arizona) — *Oracle & Tucson, AZ, USA*

Biosphere 2 Climate Control via Neural Operators and Digital Twin — *2023 – 2024*

- Performed system identification for a non-isothermal rainforest biome; built neural-operator forecasting models for control.
- Prototyped model predictive control strategies and end-to-end data pipelines for facility operations.

Skoltech — *Moscow, Russia*

Inverse Scattering and Optical Communications — *2020 – 2022*

- Analyzed pulse interactions in weakly nonlinear coherent optical communications (J. Phys.: Conf. Ser., 2021).
- Built a GPU-accelerated NLSE solver in CUDA (code).
- Explored ML–integrability hybrid methods for nonlinear fiber systems.

Ufa State Aviation Technical University — *Ufa, Russia*

Orbital Angular Momentum (OAM) Wireless and Radio-over-Fiber — *2018 – 2020*

- Designed ultra-wideband vortex antenna arrays for high-capacity wireless links; studied topology–mode purity trade-offs (J. Phys.: Conf. Ser., 2019; IEEE TELFOR, 2019).
- Developed theory for optics-to-THz OAM conversion via difference-frequency generation, including a law for topological-charge transfer; validated with numerical simulations (Computer Optics, 2019).

Ufa State Aviation Technical University — *Ufa, Russia*

Electrical Engineering and Instrumentation (Patented Devices) — *2018 – 2019*

- Designed a time-pulse integrating voltage converter combining an integrator, a double-threshold regenerative comparator, and a 4-channel analog switch; a pair of configurable followers in the comparator feedback toggles inverting/non-inverting modes to integrate a selected input and convert amplitude to pulse frequency or pulse duration (RU2689805C1, 2019).
- Designed a radio ball primary converter for liquid flow using a hollow dielectric ball with an internal LC resonator magnetically coupled to an external oscillator in an annular channel; provides frequency or pulse (voltage/current) output largely independent of liquid type and physicochemical properties (RU2685798C1, 2019).

Skoltech Summer School — *Moscow, Russia*

Research Workshop in Theoretical Physics. Microscale Chiral Propulsion — *Summer 2017*

- Selected as a winner in an international student physics competition; invited to the workshop organized by L. Levitov (MIT) and colleagues.
- Developed a Green's-function approach for Stokes-flow propulsion of chiral bodies; recovered Stokes' drag law; analyzed helical propellers; proposed optofluidic chiral sorting (arXiv:1804.08664; advisor: Prof. D. Kharzeev, Stony Brook).

Teaching

MATH 485/585 — Mathematical Modeling — *University of Arizona*

Project Mentor — *Spring 2025*

- Mentored two student groups (2–3 students each) on semester-long modeling projects based at Biosphere 2.
- Guided project scoping, model formulation, data analysis, and validation; held weekly check-ins and office hours.
- Provided feedback on proposals, final reports, and presentations; reviewed code and reproducibility.
- Coordinated with Biosphere 2 to align objectives and data needs.

MATH 581 A/B — Methods of Applied Mathematics — *University of Arizona*

Recitation Coordinator (PhD course) — *Fall 2023 – Spring 2024*

- Designed and led graduate recitations; held weekly office hours; authored select exam problems and prepared solution keys.

MATH 112 — College Algebra Concepts and Applications — *University of Arizona*

Teaching Assistant — *Fall 2023*

- Assessed student work; held weekly office hours; graded homework.

MATH 107 — Exploring and Understanding Data — *University of Arizona*

Teaching Assistant — *Spring 2023*

- Assessed student work; held weekly office hours; graded homework.

Mathematical Analysis I — *USATU*

Peer Tutor — *Fall 2016*

- Assisted first-year students with homework problem sets and core course materials during weekly help sessions.

Publications

Full list

Google Scholar (I. Kuk)

Selected

[1] **Kuk**, **I.**, Djordjevic, I. B., Gabitov, I. R., Runge, K., Ige, A. S., Deymier, P. A., Quantum logic gate analogies in nonlinear acoustics, *The Journal of the Acoustical Society of America*, vol. 157, no. 6, pp. 4437–4448, 2025. doi: 10.1121/10.0036901.

[2] **Kuk**, **I.**, Gabitov, I. R., Inverse scattering transform via affine map: Applications to high-speed nonlinear optical communications, 2025. arXiv: 2507.20470.

[3] Gibney, J., **Kuk**, **I.**, Gabitov, I., Pulse interactions in weakly nonlinear coherent optical communication links, in *Journal of Physics: Conference Series*, IOP Publishing, vol. 1890, 2021, p. 012 006. doi: 10.1088/1742-6596/1890/1/012006.

[4] Gizatulin, A. R., Meshkov, I. K., Grakhova, E. P., Ishmiyarov, A. A., **Kuk**, **I. A.**, Sultanov, A. K., Bagmanov, V. K., Abdrakhmanova, G. I., Vinogradova, I. L., Bourdine, A. V., Design of vortex optical fibers for rof systems: Part i: Overview and alternative solutions, *Optical Technologies for Telecommunications 2019*, vol. 11516, pp. 514–521, 2020. doi: 10.1117/12.2566512.

[5] Bagmanov, V. K., Sultanov, A. K., Gizatulin, A. R., Meshkov, I. K., **Kuk**, **I. A.**, Grakhova, E. P., Abdrakhmanova, G. I., Vinogradova, I. L., Optics-to-thz conversion of vortex beams using nonlinear difference frequency generation, *Computer Optics*, vol. 43, no. 6, pp. 983–991, 2019. doi: 10.18287/2412-6179-2019-43-6-983-991.

[6] Bagmanov, V. K., Sultanov, A. K., Gizatulin, A. R., Meshkov, I. K., **Kuk**, **I. A.**, Grakhova, E. P., Abdrakhmanova, G. I., Vinogradova, I. L., The vortex beams conversion from the optical range into the radio domain based on the nonlinear generation of the difference frequency, in *2019 27th Telecommunications Forum (TELFOR)*, IEEE, 2019, pp. 1–4. doi: 10.1109/TELFOR48224.2019.8971332.

[7] Grakhova, E., Meshkov, I., Abdrakhmanova, G., Bagmanov, V. K., Vinogradova, I., Gizatulin, A., **Kuk**, **I.**, Sultanov, A. K., An approach for generating and detecting the signals with the given orbital angular momentum for wireless communication systems, in *Journal of Physics: Conference Series*, IOP Publishing, vol. 1368, 2019, p. 042 038. doi: 10.1088/1742-6596/1368/4/042038.

[8] Abdrakhmanova, G., Grakhova, E., Bagmanov, V. K., Gizatulin, A., **Kuk**, **I.**, Meshkov, I., Ishmiyarov, A., Ultra-wideband vortex antenna array design for high capacity radio links, in *Journal of Physics: Conference Series*, IOP Publishing, vol. 1096, 2018, p. 012 164. doi: 10.1088/1742-6596/1096/1/012164.

[9] Aif, S., **Kuk**, **I. A.**, Kharzeev, D. E., Chiral propulsion by electromagnetic fields, 2018. arXiv: 1804.08664.

Patents

[1] **Kuk**, **I. A.**, Safinov, S. S., Time-pulse universal integrating voltage converter, Patent RU2689805C1, Application No. RU2018128886A, May 29, 2019.

[2] Safinov, S. S., **Kuk**, **I. A.**, Umetbaev, F. S., Bikbulatov, T. R., Radio ball primary converter of liquid flow, Patent RU2685798C1, Application No. RU2018119616A, Apr. 23, 2019.

Honors & Awards

International Awards

2025	**Winner of the Grogan Scholarship**, Thomas M. and Candace C. Grogan Endowed Fund, Department of Mathematics, University of Arizona	*Tucson, AZ, USA*
2018	**3rd Degree Diploma (Final Round)**, Open International Internet Olympiad – Physics (Technics & Technology)	*Online*
2017	**Winner**, International Student Physics Competition for Skoltech Summer School in Theoretical Physics	*Online*
2017	**3rd Place**, International Student Olympiad in Theoretical & General Electrical Engineering (M.O. Dolivo-Dobrovolsky)	*Ivanovo, Russia*

National Awards (Russia)

2020	**Winner's Diploma – Radio Engineering (Specialist/Master)**, All-Russian Olympiad "I am a Professional" (Season 3)	*Russia*
2020	**Presidential Scholarship of the Russian Federation**, Priority Areas of Modernization & Tech Development (2019/2020)	*Russia*
2019	**Prizewinner's Diploma – Radio Engineering (Specialist/Master)**, All-Russian Olympiad "I am a Professional" (Season 2)	*Russia*
2019	**Prizewinner's Diploma – Physics (Specialist/Master)**, All-Russian Olympiad "I am a Professional" (Season 2)	*Russia*

Workshops & Outreach

2025	**Speaker**, The Community College STEM Workshop Series (students represented 17 community colleges across the U.S.), New Frontiers of Sound Science & Technology Center, University of Arizona	*Tucson, AZ, USA*
2019	**Participant**, Ural Federal University Winter School "Software Engineering & Radio Engineering"	*Sochi, Russia*
2019	**Participant**, 5th Interregional School-Conference "Nonlinear Processes in Condensed Matter"	*Ufa, Russia*
2017	**Participant**, Skoltech Summer School in Theoretical Physics	*Moscow, Russia*

Talks

Digital Twins at Biosphere 2 Workshop — *University of Aizona*

Digital twinning for Cybernetic control: Bidirectional data feedbacks for Biosphere Biome control — *Dec. 2025*

Los Alamos – Arizona Days Conference — *Los Alamos, NM*

Inverse Scattering Transform via Affine Map Operator and Machine Learning — *Nov. 2025*

Mathematical Physics and Probability Seminar — *University of Arizona*

Perturbation theory, integrability, and data-driven modeling for fiber optics — *Oct. 2025*

Applied Math Graduate Student Brown Bag Seminar — *University of Arizona*

Shor's algorithm on a nonlinear acoustic metastructure — *Sept. 2025*

The Community College STEM Workshop Series (17 community colleges across the U.S.), New Frontiers of Sound Science & Technology Center — *University of Arizona*

Feel the Frequency: The Power of Vibrations — *Apr. 2025*

Seminar of Roald Sagdeev — *Online, University of Maryland*

How to mitigate nonlinear distortions in optical communication systems — *Mar. 2025*

Stakeholder Meeting, New Frontiers of Sound Science & Technology Center — *University of Arizona*

Quantum Logic Gate Analogies in Nonlinear Acoustics, Student Lightning Talk — *Jan. 2025*

Analysis, Dynamics and Applications Seminar — *University of Arizona*

Integrability and Inverse Scattering in the Nonlinear Schrödinger Equation — *Mar. 2024*

Applied Math Graduate Student Brown Bag Seminar — *University of Arizona*

Biosphere 2 Thermal Control Project powered by Machine Learning, Summer 2023 Research Showcase Presentations — *Aug. 2023*