



Ilia Kuk

PH.D. CANDIDATE, APPLIED MATHEMATICS · GRADUATE RESEARCHER

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Short CV available at iliakuk.com/cv

Nonlinear waves, quantum-inspired computation, and metamaterials.

Education

The University of Arizona

PH.D. APPLIED MATHEMATICS, ADVANCED TO CANDIDACY, EXPECTED MAY 2027

M.S. APPLIED MATHEMATICS, MAY 2024

Tucson, AZ, USA

Aug. 2022 – Present

Aug. 2022 – May 2024

Skoltech (Skolkovo Institute of Science and Technology)

PH.D. PHYSICS (PROGRAM STARTED), TRANSFERRED TO THE UNIVERSITY OF ARIZONA

Moscow, Russia

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)

SPECIALIST DIPLOMA (EQUIVALENT TO INTEGRATED B.S./M.S.), ENGINEER QUALIFICATION, INFOCOMMUNICATION TECHNOLOGIES

AND SPECIAL COMMUNICATION SYSTEMS

Ufa, Russia

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)

Experience

Graduate Assistant, Research

THE UNIVERSITY OF ARIZONA

Tucson, AZ

Jan. 2024 – Present

- Graduate researcher at the New Frontiers of Sound Science & Technology Center (NewFoS), The University of Arizona.

Graduate Assistant, Teaching (Mathematics)

THE UNIVERSITY OF ARIZONA

Tucson, AZ

Jan. 2023 – Dec. 2023

- Teaching assistant for undergraduate mathematics courses (discussion sections, office hours, grading).

Skills

Programming Python, C/C++

OS Linux, Windows

Tools Git, Docker, Pixi, MATLAB, Mathematica, $\text{\LaTeX}$

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

University of Arizona

Tucson, AZ

INVERSE SCATTERING AND OPTICAL COMMUNICATIONS

Aug. 2022 – Present

- Developed a data-driven affine-map formulation of the inverse scattering transform (IST) for the NLSE; derived a low-rank approximation of the map (*Physica D: Nonlinear Phenomena*, 2026).
- Developed a machine learning method to reconstruct a class of potentials from spectral data and applied it to signal recovery after nonlinear propagation in optical fiber (*SIAM NWCS*, 2024).

HYBRID SURFACE WAVES AT INTERFACES BETWEEN HYPERBOLIC METAMATERIALS AND TOPOLOGICAL INSULATORS

Feb. 2026 – Present

- Derived analytical dispersion relations and localization conditions for hybrid TE and TM surface waves at interfaces between uniaxial hyperbolic metamaterials and topological insulators, incorporating topological magnetoelectric coupling for two orientations of the optical axis.
- Identified finite propagation windows separated by forbidden frequency bands and quantified mode confinement through penetration depths, showing how the orientation of the optical axis controls spectral existence domains and surface localization; accepted for oral presentation at *Metamaterials 2026*.

New Frontiers of Sound Science & Technology Center (University of Arizona)

Tucson, AZ

QUANTUM-INSPIRED COMPUTING IN NONLINEAR AND TOPOLOGICAL ACOUSTICS

Sep. 2023 – Present

- Realized the period-finding core of Shor's algorithm using phase-bit (*phibit*) logic on a topological acoustics platform; published in *Communications Engineering*, 2026; related patent filed: United States Provisional Patent Application No. 63/922,866, "Topological Acoustic Phase Bits With Improved Computational Features," filed November 21, 2025.
- 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).

Biosphere 2 (University of Arizona)

Oracle & Tucson, AZ

MACHINE LEARNING FOR BIOSPHERE 2 THERMAL CONTROL

Summer 2023

- Developed one- and two-dimensional Fourier neural operator architectures to predict thermal control trajectories from multivariate environmental sensor data, incorporating calendar and time embeddings and residual spectral layers.
- Built a PyTorch Lightning pipeline that extracts and aligns sensor and control measurements from Biosphere 2 Oracle databases, preprocesses the data, trains and evaluates models on GPUs, and tracks experiments (code: <https://github.com/CosmosRedshift7/biosphere>).

BIOSPHERE 2 DIGITAL TWIN

2023 – 2024

- Developed a digital-twin framework for the Biosphere 2 Tropical Rainforest biome that combines facility measurements, physical models, and reduced order surrogates for system identification, forecasting, uncertainty quantification, and model predictive control.
- Implemented and analyzed a 2D incompressible Navier–Stokes model with the Boussinesq approximation in OpenFOAM; performed mesh convergence and sensitivity studies of inlet conditions (code: <https://github.com/arnold-pdev/atmosphere2>).
- The project received a University of Arizona Institute for Energy Solutions *Innovative Projects in Energy* grant for "Climate Control of Non-Isothermal Spaces under Uncertainty."

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: <https://github.com/CosmosRedshift7/NLSE-CUDA>).
- Investigated nonlinear intrachannel interactions arising from dispersive pulse overlap and four-wave mixing in coherent optical-fiber links; characterized the statistical properties of distorted output pulses and proposed a method for nonlinearity compensation (*SIAM NWCS*, 2022); *SIAM Annual Meeting*, 2021.
- Explored Machine Learning and Integrability hybrid methods for nonlinear fiber systems.

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](https://arxiv.org/abs/1804.08664); advisor: Prof. D. Kharzeev, Stony Brook).

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).

- 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).

Teaching

MATH 485/585 — Mathematical Modeling

University of Arizona

PROJECT MENTOR

Spring 2026

- 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 LEVEL 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.

Calculus 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 \(Ilia Kuk\)](https://scholar.google.com/citations?user=B7RqVKYAAAAJ): <https://scholar.google.com/citations?user=B7RqVKYAAAAJ>

SELECTED PEER-REVIEWED JOURNAL ARTICLES

- [1] **Kuk, I.**, Djordjevic, I. B., Runge, K., Gabitov, I. R., Deymier, P. A., [Realizing Shor's algorithm with topological acoustic phase bits](#), *Communications Engineering*, vol. 5, no. 1, p. 60, Feb. 2026. doi: 10.1038/s44172-026-00623-6.
- [2] **Kuk, I.**, Gabitov, I. R., [Inverse scattering transform via affine map: Applications to high-speed nonlinear optical communications](#), *Physica D: Nonlinear Phenomena*, vol. 496, p. 135 344, 2026. doi: <https://doi.org/10.1016/j.physd.2026.135344>.
- [3] **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.
- [4] 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.

SELECTED PEER-REVIEWED CONFERENCE ARTICLES

- [5] 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.
- [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.

SELECTED CONFERENCE ABSTRACTS

- [9] **Kuk, I.**, Gabitov, I. R., [Machine learning and inverse scattering transform: Data recovery in optical fiber](#), in *SIAM Conference on Nonlinear Waves and Coherent Structures*, Presented by Ildar Gabitov, 2024.
- [10] Gabitov, I. R., Gibney, J., **Kuk, I.**, [Nonlinearity and optical fiber communications: New aspects of an old problem](#), in *SIAM Conference on Nonlinear Waves and Coherent Structures*, Presented by Ildar Gabitov, 2022.
- [11] Gabitov, I. R., Gibney, J., **Kuk, I.**, [Pulse overlap and nonlinear intrachannel interactions in coherent telecommunication lines](#), in *SIAM Annual Meeting*, Presented by Ildar Gabitov, 2021.

SELECTED PREPRINTS

- [12] Aif, S., **Kuk, I. A.**, Kharzeev, D. E., [Chiral propulsion by electromagnetic fields](#), 2018. arXiv: 1804.08664.

Patents

ISSUED

- [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.

PENDING

- [3] Gabitov, I. R., **Kuk, I.**, Deymier, P. A., Runge, K., Djordjevic, I. B., Topological acoustic phase bits with improved computational features, United States Provisional Patent Application 63/922,866, Filed November 21, 2025.

Professional Service

PEER REVIEW

2026 **Reviewer**, Journal of Nonlinear Science

CONFERENCE ORGANIZATION

2026 **Co-organizer, special session “Nonlinear Waves, Integrable Systems, and Inverse Scattering”**, scheduled *Arizona State University*
November 2026, American Mathematical Society (AMS) Fall Western Sectional Meeting

TECHNICAL PROGRAM COMMITTEES

2026 **Technical Program Committee Member**, IEEE Global Communications Conference (GLOBECOM) *Macau, China (Online)*

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 **President of the Russian Federation Scholarship**, Priority Areas of Modernization and Tech Development (2019/2020), awarded competitively for outstanding academic and research achievements *Russia*

2020 **Winner’s Diploma – Radio Engineering (Specialist/Master)**, All-Russian Olympiad “I am a Professional” (Season 3) *Russia*

2019 **Prizewinner’s Diploma – Radio Engineering (Specialist/Master)**, All-Russian Olympiad “I am a Professional” (Season 2) *Russia*

Professional Development

2026	Participant , Arizona-Livermore Days Conference	<i>Tucson, AZ</i>
2019	Participant , Ural Federal University Winter School “Software Engineering & Radio Engineering”	<i>Sochi, Russia</i>
2019	Participant , 5th Interregional School-Conference “Nonlinear Processes in Condensed Matter”	<i>Ufa, Russia</i>
2017	Participant , Skoltech Summer School in Theoretical Physics	<i>Moscow, Russia</i>

Outreach

SPEAKER: “ON APPLICATIONS OF THE RESEARCH + WAVES: MATHEMATICAL DESCRIPTION OF VIBRATIONS”	<i>Mar. 26, 2026</i>
Community College STEM Workshop Series (17 U.S. community colleges), New Frontiers of Sound Science & Technology Center	<i>University of Arizona</i>
VOLUNTEER: WEBSITE COORDINATOR AND TECHNICAL SUPPORT	<i>Mar. 21–22, 2026</i>
USA(J)MO Host Site, Mathematical Association of America (MAA) Set up and maintained the official event webpage under the University of Arizona domain.	<i>University of Arizona</i>
SPEAKER: “FEEL THE FREQUENCY: THE POWER OF VIBRATIONS”	<i>Apr. 2025</i>
Community College STEM Workshop Series (17 U.S. community colleges), New Frontiers of Sound Science & Technology Center	<i>University of Arizona</i>

Talks

Invited Talks

PERIOD-FINDING COMPUTATION IN A NONLINEAR ACOUSTIC METAMATERIAL STRUCTURE	<i>May 2026</i>
190th Meeting of the Acoustical Society of America, Session: Computation in Phononics and Metamaterials	<i>Philadelphia, PA</i>

Conferences and Workshops

BE THE ALGORITHM: CONTROLLING A BIOME WITH DATA	<i>Apr. 4, 2026</i>
University of Arizona Innovations in Graduate Education (IGE) and SIAM Roundtable & Workshop on Scientific Computing	<i>University of Arizona</i>
TOPOLOGICAL ACOUSTIC PHASE BITS FOR SHOR’S ALGORITHM	<i>Jan. 2026</i>
2026 Stakeholder Meeting, New Frontiers of Sound Science & Technology Center	<i>University of Arizona</i>
DIGITAL TWINNING FOR CYBERNETIC CONTROL: BIDIRECTIONAL DATA FEEDBACKS FOR BIOSPHERE BIOME CONTROL	<i>Dec. 2025</i>
Digital Twins at Biosphere 2 Workshop	<i>University of Arizona</i>
INVERSE SCATTERING TRANSFORM VIA AFFINE MAP OPERATOR AND MACHINE LEARNING	<i>Nov. 2025</i>
Los Alamos – Arizona Days Conference	<i>Los Alamos, NM</i>
QUANTUM LOGIC GATE ANALOGIES IN NONLINEAR ACOUSTICS	<i>Jan. 2025</i>
2025 Stakeholder Meeting, New Frontiers of Sound Science & Technology Center	<i>University of Arizona</i>

Seminars

PERTURBATION THEORY, INTEGRABILITY, AND DATA-DRIVEN MODELING FOR FIBER OPTICS	<i>Oct. 2025</i>
Mathematical Physics and Probability Seminar	<i>University of Arizona</i>
HOW TO MITIGATE NONLINEAR DISTORTIONS IN OPTICAL COMMUNICATION SYSTEMS	<i>Mar. 2025</i>
Seminar of Roald Sagdeev	<i>University of Maryland (Online)</i>
INTEGRABILITY AND INVERSE SCATTERING IN THE NONLINEAR SCHRÖDINGER EQUATION	<i>Mar. 2024</i>
Analysis, Dynamics and Applications Seminar	<i>University of Arizona</i>