2025 IEEE Workshop and Summer School on Photonics Automation

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List of Abstracts

Keynote speakers

Prof. Gabriele Grosso (ASRC CUNY): Photoluminescence spectroscopy automation for quantum optoelectronics

In this presentation, we highlight recent advancements in controlling the emission of classical and quantum light in low-dimensional materials through advanced experimental techniques. We begin by reviewing key experimental procedures developed in our laboratory and show how automation of photoluminescence spectroscopy enables sophisticated and high-throughput photonic investigations. We then present our latest results from the characterization of artificial atomic structures in two-dimensional (2D) materials. The first part focuses on defect-based quantum emitters in wide bandgap materials and their potential applications in scalable quantum photonic technologies. In the second part, we explore light–matter interactions at phase interfaces in 2D semiconductors, specifically transition metal dichalcogenides (TMDs). Finally, we introduce methods for visualizing dark excitons, revealing their long-range transport enabled by enhanced interactions, and discuss their potential for use in strain sensing applications.

Bio: Gabriele Grosso is an Assistant Professor of Physics at the Advanced Science Research Center and the Graduate Center of CUNY. He received his B.S. and M.S. in Physics from the University of Padova. During his master's studies, he was a visiting researcher at the University of California, San Diego. He earned his Ph.D. in Physics from the École Polytechnique Fédérale de Lausanne (EPFL), where he studied polariton quantum fluids. He then joined the Quantum Photonics Group at the Massachusetts Institute of Technology (MIT) as a postdoctoral researcher. Gabriele is a former fellow of the Swiss National Science Foundation and a recipient of the NSF CAREER award. His research focuses on quantum technologies based on light–matter interactions in two-dimensional van der Waals materials and other quantum-confined systems.

Prof. Haogang Cai (NYU): Inverse design of meta-optics using Python

Optical metasurfaces enable abrupt wavefront engineering by locally controlling the light properties (amplitude, phase, etc.). Meta-optics hold great potential to promote a new generation of ultra-compact optical systems. Inverse design strategies have been developed to either improve the optical performance or enable novel functions. In this talk, I will briefly overview the conventional forward design method based on meta-atom library search, and then present two different inverse design examples. Firstly, we demonstrated ultrathin 2D metasurfaces (thickness ~ 1/5 of the wavelength) with nonlocal interactions. We developed a global evolutionary optimization approach based on the genetic algorithm, which improves the resonant metalens focusing efficiency by more than 50%. The optimized designs were experimentally validated based on nanofabrication using electron beam lithography. Secondly, I will also introduce the inverse design of 3D metamaterials with novel multi-functions using the adjoint method. We develop 3D meta-optics to leverage the wealth of invisible wavefront information (e.g., polarization, spatial mode, etc), which are fabricated by two-photon polymerization (TPP) lithography. For both examples, Python is the preferred programing language, taking advantages of available packages for automatic scientific computing and interfacing with FDTD simulation software (Lumerical).

Bio: Dr. Haogang Cai is an assistant professor in the Tech4Health Institute and Department of Radiology, at New York University. He has a cross-appointment with the Department of Biomedical Engineering, and is also a member of the Perlmutter Cancer Center, NYU Langone Health. Before joining NYU in 2020, Dr. Cai had postdoctoral trainings at Columbia and Argonne National Laboratory respectively. He received his PhD from the Department of Mechanical Engineering at Columbia University in 2016. Dr. Cai is a receipt of numerous awards, including 2022 Maximizing Investigators' Research Award (MIRA) from National Institute of Health (NIH), 2025 CMBE Rising Stars Award from Biomedical Engineering Society (BMES). His research interests span multidisciplinary topics including biomedical and nanoengineering, optical metasurfaces for bioimaging and biosensing.

Prof. Euclides Almeida (Queens College CUNY): Engineering Nonlinear Metasurfaces for Light Generation and Control

Nonlinear metasurfaces are an emerging class of ultrathin optical elements that enable the generation and control of coherent light through engineered nonlinear optical processes. By leveraging subwavelength structuring, these metasurfaces can facilitate strong light–matter interactions, leading to enhanced harmonic generation, frequency mixing, and other nonlinear effects in compact, planar geometries. Their unique ability to integrate nonlinear generation and wavefront shaping within a single platform opens new avenues for applications in holography, ultrafast optics, nonlinear imaging, and quantum technologies.

In this talk, I will present a comprehensive review of nonlinear metasurfaces, with an emphasis on the technical foundations of their design, fabrication, and characterization. I will discuss key design strategies—including material selection, resonant enhancement, and symmetry control—that enable efficient nonlinear responses. The talk will also address challenges in fabrication of nonlinear metasurfaces and measurements of nonlinear signals. Finally, I will explore recent efforts toward automating each stage of the development pipeline, including the use of inverse design, and highlight future directions for reconfigurable nonlinear metasurface technologies.

Bio: Euclides Almeida is an Assistant Professor of Physics at Queens College of the City University of New York (CUNY) and a faculty member in the Physics Ph.D. Program at the CUNY Graduate Center. He received his Doctor of Science (D.Sc.) degree in Physics from the Federal University of Pernambuco, Brazil, in 2012, and conducted postdoctoral research at the Weizmann Institute of Science from 2012 to 2017. Prof. Almeida's research focuses on nanophotonics, nonlinear optics, and metamaterials, with an emphasis on light–matter interactions at the nanoscale. His work aims to develop novel photonic platforms for optical signal processing, coherent light generation, biosensing, and quantum technologies.

Prof. Eileen Otte (University of Rochester) Beyond the Beam: The Potential of Light's Structure

When light interacts with a medium, its spatial structure – including amplitude, phase, polarization, angular momenta, and more – is shaped by the medium's properties across scales, from the macro to the nanoscale. For example, sunlight scattered in the blue daylight sky exhibits intriguing polarization patterns that encode the sun's position—imperceptible to humans but used by insects like bees for navigation. At much the smaller, molecular level, the emission pattern of a single fluorescent molecule depends on its dipole orientation, allowing nanoscale features to be decoded from the structured light it emits.

Inversely, structured light can also be deliberately engineered, making it a powerful tool across a wide range of applications, including optical micro- and nano-manipulation, motion sensing, material machining, and classical as well as quantum communication and encryption. Used in quantum key distribution, structured light increases the dimension, enhancing the information capacity per photon, noise resilience, and transmission distance.

We will explore how encoding and decoding information in the structure of light opens new avenues for advancing cutting-edge applications and emerging technologies.

Bio: Dr. Eileen Otte joined the Institute of Optics at the University of Rochester as a new faculty member in January 2025. Before, she was a postdoctoral fellow at the Geballe Laboratory for Advanced Materials (GLAM), Stanford University, advised by Prof. Mark Brongersma. Eileen's research concentrates on the fundamental properties and diverse applications of structured light fields, in areas such as singular optics, nanoscale imaging and sensing, quantum cryptography, optical manipulation, and more. In her postdoctoral research, Eileen focused on nanoscale light-matter interactions, combining structured light and nanophotonics.

Eileen performed her PhD work at the University of Muenster, Germany, and University of the Witwatersrand, South Africa; it was honored with summa cum laude as well as the WWU Dissertation Award, and published as a book in the Springer Theses series. She has also received the Research Award 2020 of the Industrial Club Duesseldorf, was appointed a junior class member of the NRW Academy of Sciences, Humanities, and the Arts, and was listed among the Emerging Leaders 2021 and Emerging Talents 2021 of IOP's Journal of Optics. Her postdoctoral research was supported by the PRIME fellowship of the German Academic Exchange Service as well as Stanford's GLAM Postdoctoral Fellowship.

Prof. Samantha Roberts (ASRC CUNY): Generative AI for Research

Generative AI tools—especially large language models (LLMs) and emerging multimodal models—are rapidly changing how researchers interact with information. This talk begins with a high-level overview of how these models work, setting realistic expectations for their capabilities and limitations. With that foundation, we'll explore how generative models can streamline research workflows, from code generation and data analysis to literature review, scientific writing, and knowledge organization.

We'll focus on strategies to make these systems more trustworthy and useful by grounding them in curated, domain-specific content. Retrieval-augmented generation (RAG) and vector-based search are key methods for making this possible, enabling models to reference authoritative sources and deliver more context-aware outputs. Finally, we'll explore what it means to build "AI-ready" documentation—highlighting how labs and research teams can structure their digital knowledge today to fully leverage AI-enhanced tools in the future.

Bio: Samantha Roberts, Ph.D., has served as Director of the ASRC Nanofabrication Facility and Research Assistant Professor since 2022. She earned her Ph.D. in Physics from Cornell University in 2014, conducting research in the Laboratory of Atomic and Solid Physics. Dr. Roberts is an expert in designing and fabricating electrical, photonic, biological, and mechanical nanoscale devices across a range of materials. With two decades of experience in academic shared-user facilities—including Cornell, Columbia, CUNY ASRC, Brookhaven National Lab, Princeton, and UPenn—she brings deep technical knowledge and operational expertise to managing cutting-edge nanofabrication environments.

Outside of her formal academic role, Dr. Roberts independently develops applications using pre-trained Generative AI models. She is the creator of nanobot.chat, a domain-specific chatbot for nanofabrication knowledge management. Her focus lies in building GenAI tools that automate tasks and support knowledge workflows in highly specialized domains. She is a strong advocate for using Generative AI to accelerate and enhance research methodologies—not as a replacement for domain expertise, but as a powerful tool to improve efficiency and discovery.

Invited speakers

Dr. Matthew C. Strasbourg (Columbia University): Practical Python in the lab: high-throughput optical spectroscopy of quantum materials

Specialized spectroscopies often necessitate custom hardware solutions, creative implementations of instrumentation, real-time data visualization, and traceable analysis of big datasets. While some software packages and programming languages excel at individual aspects of these tasks, Python is uniquely positioned to excel in these applications due to its ubiquity in scientific computing, while also avoiding the overhead associated with other solutions. This talk will cover how automated instrumentation is integrated into optical assemblies and how advanced open-source visualization toolkits and transparent analysis pipelines are utilized to interpret resulting datasets. Additionally, the talk will overview a microscope control platform and data analysis pipeline with specific examples of the complete lifecycle of a custom spectroscopic measurement, including hardware integration, measurement orchestration, data processing, and publication-ready figure rendering. It will highlight instances where automation has directly led to new scientific insights and how this Python-enabled framework supports high-throughput and specialized spectroscopy of quantum materials.

Bio: Matt is a Postdoctoral Research Scientist at Columbia University who is developing new measurement techniques that probe emergent many-body effects in 2D materials, imaging materials at the nanometer length scale, and manipulating quantum states of light. He completed his PhD in Physics at Montana State University in 2023, where he utilized low-temperature optical spectroscopy to investigate excited-state thermalization in systems with strong Coulomb interactions and quantum emitter formation in 2D semiconductors. In 2024, he joined the Department of Mechanical Engineering at Columbia, where he now specializes in near-field optical spectroscopy of quantum materials.

Dr. Deepankur Thureja (Harvard University): Disentangling weakly coupled modes via global fitting of optical spectra

Coupled oscillators are a ubiquitous theme in photonics. They provide a unifying language for phenomena involving hybridized modes in diverse platforms, ranging from ultracold atomic gases to semiconductors in optical microcavities. For spectroscopists, this often translates into the routine task of fitting complex spectral features to extract quantitative information from their optical measurements, such as resonance positions, linewidths, and interaction strengths.

In this talk, I present a special case encountered in my own research: a Feshbach resonance in a van der Waals heterostructure involving two excitonic modes – one optically bright, the other entirely dark. In particular, since the coupling strength is much smaller than the intrinsic excitonic linewidth, the interaction is effectively invisible in any single spectrum. Yet, I show how a global fitting strategy overcomes this challenge to reveal the underlying physics.

This case study serves as a practical guide for tackling ill-conditioned spectral regression problems. I will walk through a staged fitting pipeline developed in Python: beginning with single-oscillator fits to constrain background parameters, propagating uncertainties across stages, enhancing sensitivity in the anticrossing region via weighted residuals, and ultimately isolating the hidden coupling strength. This approach offers a practical blueprint for extracting quantitative insight from spectroscopic data even when key features remain hidden to the eye.

Bio: Deepankur Thureja performed his doctoral research in the Mechanical Engineering and Physics departments at ETH Zurich in the lab of Prof. David Norris and Prof. Atac Imamoglu, where he pioneered electrically tunable quantum confinement of excitons in 2D materials. As a HQI postdoctoral fellow in the group of Prof. Hongkun Park and Prof. Mikhail Lukin at Harvard University, he is exploring strong light-matter interactions in atomically thin semiconductors to advance the development of a solid-state quantum many-body system made of strongly correlated photons.

Sarah Jane Baker (ASRC CUNY): Automating Data Collection using Python

Coordinating multiple instruments in photonics experiments often requires manual intervention, which can slow data collection and limit reproducibility. In this talk, I will present how I used Python to automate these processes for an experiment I built to measure changes in photoluminescence as a function of applied magnetic field. The Python script I developed controls three instruments simultaneously: a cryostat that sets and stabilizes both the magnetic field and temperature, a mechanical shutter that protects the sample from continuous excitation, and a lock-in amplifier that receives the collected signal. Between each magnetic field setpoint, the script automatically triggers measurements, adjusts experimental conditions, and updates two live plots for real-time visualization. This streamlines long experimental sessions, reduces sample degradation and manual errors, and provides insight into the evolving dataset. The tools and strategies I will share are broadly applicable to many photonics setups that require inter-instrument communication and live data monitoring.

Bio: Sarah's research is at the intersection of nanoscience and photonics. She seeks to develop more efficient photovoltaics to make solar energy harvesting practical to implement on larger scales. Her goal is to use singlet fission macromolecules to drive multielectron photocatalytic reactions. The model frequently used to depict singlet fission discounts the potential for direct harvesting from the coupled biexciton (triplet pair) state—the intermediate state between the singlet and two "free" triplets—in artificial photosynthetic processes. Sarah aims to optimize energy harvesting by understanding how chromophore design, including descriptions of quantum interference, controls the nature and lifetime of triplet pair states.

She will use these concepts to demonstrate how individual triplet excitons can be directly extracted from a triplet pair prior to dissociation, avoiding certain loss-prone processes and ultimately harvesting more energy from less sunlight than current technology allows. Outside of her research, Sarah enjoys drawing, baking, and spending time in the Catskills.

Dr. Michael de Oliveira (ASRC CUNY): Shaping Light on Demand (with a Few Lines of Code)

Imagine sculpting light—twisting, shaping, and imprinting it with structure—as effortlessly as editing an image on a screen. In today's photonics labs, this is no longer a fantasy. Spatial light modulators (SLMs) have become versatile, programmable tools that enable real-time control over light's spatial and temporal properties, driving advances in areas like microscopy, optical tweezing, quantum optics, and beyond. This talk offers an accessible introduction to the principles and practice of shaping light with SLMs. We'll unpack how these devices work, how phase-only modulation can be used to encode both phase and complex amplitude, and and how to generate a wide range of structured beams—from optical vortices and exotic modes to dynamic space-time beams. We'll walk through intuitive examples, practical strategies, and common challenges, making this tutorial especially valuable for those new to SLMs or curious about integrating them into automated experimental setups. Whether you're steering beams, engineering light fields for nonlinear optics, or encoding information for quantum communication, this session will provide a clear and engaging foundation for shaping light in the lab.

Bio: Michael de Oliveira spends most of his time convincing light to do increasingly strange and complicated things—twist, spin, heal, or dance through space-time—using devices like spatial light modulators, metasurfaces and a generous dose of stubborn optimism. His research focuses on shaping light across multiple degrees of freedom—phase, polarization, amplitude, frequency, and time—to unlock new effects in photonics, from ultrafast and nonlinear optics to quantum experiments. He firmly believes that light is just misunderstood—and that with enough patience, whispered incantations to Maxwell, and elaborate alignment rituals, it can be made to do almost anything. Probably.

Michael joined the ASRC and Prof. Andrea Alù's group in 2025 as a Postdoctoral Research Fellow. He earned his PhD in Physics from the Politecnico di Milano in collaboration with the Italian Institute of Technology, where he worked under the supervision of Dr. Antonio Ambrosio on multi-degree-of-freedom control of light for advanced photonic applications. Before that, he completed his BSc in Astronomy & Astrophysics, BSc (Honors), and MSc in Physics with distinction at the University of the Witwatersrand in South Africa, where he began working with structured light under Prof. Andrew Forbes.

Dr. Pratap Chandra Adak (CCNY CUNY): Magnon-mediated exciton-exciton interactions in a van der Waals antiferromagnet

CrSBr is a newly discovered material that uniquely combines magnetism with semiconducting properties at the atomic scale. It hosts excitons—bound pairs of electrons and holes—that strongly influence its optical behavior. What makes CrSBr truly remarkable is that these excitons interact with the material's magnetic state, leading to a new type of coupling between excitons and magnons—the quantum ripples of magnetism. In our recent experiments, we have uncovered how this exciton-magnon interaction enables an indirect interaction between excitons themselves, resulting in strong nonlinear optical effects. This interaction is unusual because excitons and magnons typically do not interact with each other, but in CrSBr, the magnetic environment subtly changes as excitons accumulate, shifting their energy. Our findings deepen our understanding of emergent quasiparticle interactions in quantum materials and point toward promising applications, such as devices that can link microwave and optical signals—useful for next-generation quantum communication.

Bio: Dr. Pratap Chandra Adak is a postdoctoral researcher at the City College of New York, working under the guidance of Prof. Vinod Menon. His current research focuses on the interaction of light with two-dimensional (2D) magnetic materials, particularly CrSBr. He has contributed to the discovery of a novel exciton-exciton interaction mediated by magnetic excitations (magnons), enabling strong optical nonlinearities—an advance with potential applications in next-generation photonic and quantum devices. Before this, he earned his Ph.D. from the Tata Institute of Fundamental Research (TIFR) in Mumbai, where he investigated quantum transport in 2D systems such as graphene. His doctoral work revealed a form of the Hall effect that arises not from external magnetic fields, but from the topological structure of flat bands in twisted double bilayer graphene. He is also deeply interested in leveraging Python-based automation for high-throughput experiments and data-driven insights into experimental results.

Contributed Talk

Sophia Sechi (University of Cagliari): Automation of a mid-infrared pump-probe spectroscopy setup

Ultrafast pump-probe spectroscopy enables the study of nonequilibrium dynamics in materials on femtosecond timescales. In our setup, mid-infrared pump and probe pulses excite and track phonon resonances in low-symmetry systems. The probe beam is imaged with a mid-IR camera, providing access to both real and momentum (k-) space and allowing investigation of anisotropic dynamics and dispersion phenomena. A motorized delay stage controls the time delay between pulses, while a collinear interferometer analyzes the probe's spectral components.

LabVIEW software coordinates the entire experiment, synchronizing the camera, translation stage, and interferometer for streamlined data acquisition. This integrated approach enables us to capture both temporal and spectral information, making it possible to visualize ultrafast, direction-dependent processes in complex materials and providing a powerful tool for condensed matter research.

Bio: Sofia Sechi earned her Bachelor's degree in Physics from the University of Cagliari (Sardinia, Italy) in 2024 and is currently pursuing a Master's degree in Photonics and Nanomaterials at the same institution. She is carrying out her thesis research at the ASRC within Professor Andrea Alù's group, working together with postdoctoral researcher Michele Guizzardi. Her work focuses on advanced pump-probe experiments in the mid-infrared range, investigating ultrafast dynamics of phonons in low-symmetry metamaterials.