

ACADIA PHYSICS SEMINAR

CAP LECTURE SERIES

Taming the Electromagnetic Vacuum: Harnessing Quantum Vacuum Fluctuations in Electromagnetic Cavities for Quantum Technologies Applications

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Astronomy
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Monday, March 17, 2025 at 4:30 pm

Acadia Divinity College Langley Classroom (**DIV 217**)

According to quantum mechanics, a vacuum isn't completely empty; rather, it is filled with quantum fluctuations, which can be imagined as a foam of particles constantly appearing and disappearing at very short timescales. When we enclose a region of vacuum with walls that are impenetrable to certain types of particles, we create a cavity where the properties of these quantum fluctuations can be engineered. One of the most famous phenomena arising from this is the Casimir effect, which is the emergence of attractive force between the mirrors of an optical cavity due to the modified structure of quantum vacuum fluctuations of photons. In recent years, the engineering of electromagnetic vacuum fluctuations has been actively explored, revealing promising applications in quantum metrology (such as superresolution imaging) and quantum computing. Furthermore, it is now anticipated that we may be able to engineer material properties (such as superconducting transition temperature) by placing them inside electromagnetic cavities. However, the field is still far from mature, with many fundamental questions remaining unanswered (and probably unposed). In my talk, I will start with the basics and explain the origin of the Casimir effect. I will then discuss the concept of "squeezed" vacuum and its applications in metrology and quantum computing. Finally, I will provide a brief overview of current "hot" topics in the field, including cavity material engineering and the properties of quantum fluctuations in far-from-thermal-equilibrium systems.

Ivan Iorsh received his Bachelor's (2007) and Master's degree (2009) from Saint Petersburg Polytechnic University, Russia, and completed his PhD in condensed matter physics at Durham University, UK. He has worked as a postdoctoral researcher at ITMO University in Russia and Nanyang Technological University in Singapore. Since 2018, he has been a faculty member at ITMO University and later served as a visiting researcher at the Weizmann Institute of Science in Israel. In January 2024, Ivan joined the faculty of the Department of Physics, Engineering Physics Astronomy at Queen's University. Dr. Iorsh's research focuses on the intersection of quantum optics, nanophotonics, and condensed matter theory. He investigates light-matter coupling in nanostructures and explores how this coupling can be engineered to generate quantum light and probe as well as tailor quantum correlations in matter. He is the author of over 100 papers published in highly regarded journals, including Nature Photonics, Nature Communications, and Physical Review Letters. He has supervised numerous graduate students, many of whom are now pursuing research careers at top-ranked universities worldwide.

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