# ACADIA PHYSICS SEMINAR

## When Particles Make Up Their Mind: Quantum Measurement and the End of Local Realism

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**Friday, November 14, 2025 at 12:30 pm**
**Huggins Science Hall 206 (HSH 206)**

In our everyday world, light seems to behave in entirely predictable ways — illuminating rooms, reflecting from surfaces, passing cleanly through glass. Yet when we dig deeper, that simplicity dissolves. If light is made up of individual photons, how does each one "decide" whether to pass through a window or be reflected back? Is that outcome random, or is it somehow predetermined? What seems like an elementary question turns out to challenge our most basic ideas about how nature behaves, and it lies at the heart of the mysteries of quantum mechanics.

In this talk, I will use this familiar example to illustrate how physicists have, since the birth of quantum theory, struggled with its apparent inherent randomness and nonlocality. Early interpretations sought to preserve the comforting ideas of determinism and locality by proposing that quantum particles could carry additional information — so-called *hidden variables* — that predetermined outcomes. For many years, it seemed plausible that such hidden variables could exist without contradicting quantum predictions.

A key turning point came in 1964, when John Bell demonstrated that this hope could not be sustained: the predictions of quantum mechanics are fundamentally incompatible with any theory based on local hidden variables. Over the following decades, experimentalists designed ever more refined tests of Bell's inequalities, pushing the limits of technology to close every possible "loophole". I will discuss how these efforts have deepened our understanding of the role of nonlocality in quantum theory, culminating in the remarkable "loophole-free" Bell tests of the past decade, bringing us closer to answering one of the most profound questions in physics: how, and when, is a quantum particle truly measured?

Deny Hamel did his undergraduate studies in physics at the Université de Moncton. He then completed his master's (2010) and his doctorate (2013) at the Institute for Quantum Computing in Waterloo as a Vanier scholar, pursuing the development of entangled photon sources. He subsequently continued his work in quantum information as a postdoctoral researcher at the University of Vienna. In 2014, he returned to the Université de Moncton, his alma mater, as a professor. Since 2017, he is the Canada Research Chair in Optics and Quantum Information.

Dr. Hamel's main research interests are in the field of quantum photonics, which aims to harness the quantum properties of lights to enable innovative technologies such as quantum cryptography and quantum computers. His research aims to create new tools to better put quantum light to use, focusing particularly on means of generating and manipulating quantum light. In recent years, his research team has notably made significant contributions in showing how cascaded downconversion, a novel approach to produce entangled three-photon states, can be useful for quantum technologies.