U. of T. Laser Cooling and Quantum Optics Group "

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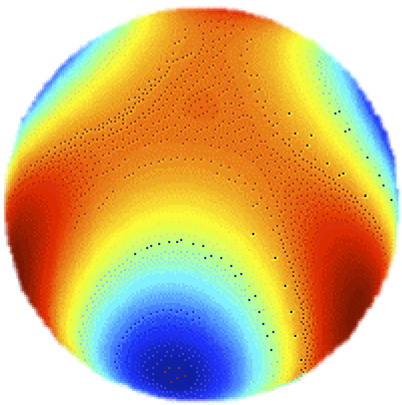
In our group, we study novel quantum-mechanical phenomena from two perspectives: ultracold atoms and ultra-correlated photons. A great deal of information, including some pictures and links to several of our articles, is available at our website.



Ultra-correlated photons: By "splitting" photons into pairs of strongly correlated photons, we are able to directly observe the quantum nature of light. Not only does this make possible tests of fundamental philosophical issues in quantum mechanics, but it has recently been realized that these correlations can be used for high-precision time measurements, ultra-secure "quantum cryptography," and even an effect known as "quantum teleportation." Our current and likely upcoming projects include using these pairs to investigate what "quantum agents" would be like, to design and implement schemes to measure the "wavefunction of the quantum vacuum," and to develop new protocols for specialized quantum data compression.

Ultracold atoms: Using laser beams and magnetic fields, we can trap and cool Rubidium atoms in a vacuum chamber to Bose-Einstein condensation, essentially absolute zero for our purposes. These atoms have such small momenta that they act like quantum waves rather than classical particles. We have recently used these condensates to measure the time atoms spend tunneling through barriers formed by intense laser beams. Future projects will extend these studies to deal with "atom resonators" and matter-wave lensing, as well as to study the time-dependence of quantum measurements. In parallel, we pursue the development of two-photon "quantum logic gates" mediated by atoms, and fundamental studies of "what a photon is doing" while propagating through a cloud of absorbing atoms.

Undergraduate research possibilities We welcome one or two interested undergraduate students to join us for the summer, typically for 4 months, to work on these projects. Although all group members are expected to be familiar with both subjects, a student would choose one of the two to concentrate on. Typical projects might include setting up a modulation system to steer laser beams and design complex shapes for our barrier potentials; building and characterizing diode modules for single-photon counting; or writing code to analyze images of trapped atoms and extract information about their quantum-mechanical wave functions.
The ideal student will have completed 3 or 4 years of physics, although exceptional 2nd-year students will be considered. Experience with optics or atomic physics or computer programming is a plus but not essential.