University of Crete
Department of Physics

Physics Colloquium

Monday, 21 July 2025 | 11:00 – 12:00, Seminar Room 3rd Floor

From Nanostructures to Qubits: Optical Control of Quantum Spins

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ABSTRACT

Quantum technologies promise to revolutionize computing, communication, and sensing. At the heart of this quantum future are systems that can reliably store and manipulate individual units of quantum information, known as qubits [1]-[3]. One particularly promising approach uses spins of electrons trapped in semiconductor quantum dots, which are nanostructures often called "artificial atoms."

In this talk, I will present recent work from the Experimental Quantum Nanoscience Lab at the University of Strathclyde [4], where we explore how to control these spin-based qubits using only light, a major step toward building practical on-chip quantum processors. Working with collaborators in Germany and Ireland, we demonstrate how to prepare and manipulate the spin states of individual quantum dots using unconventional orientations of magnetic fields [5], which gives us new flexibility in engineering the quantum properties of these systems. This allows us to create and control custom spin states with high precision, perform essential quantum logic operations, and initialize the system with very high fidelity using all-optical techniques.

In addition, we are investigating new types of scalable quantum dot platforms, where the positions of the dots can be precisely controlled during fabrication [6]. This is a key requirement for building larger quantum devices. In these systems, we have also demonstrated the ability to optically prepare [7] and control spin states [8] with excellent performance.

Overall, this work lays important groundwork toward building scalable, light-driven quantum devices, and I will discuss how our lab's results contribute to the broader landscape of quantum technologies and nanophotonics.

References

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[5] K. Barr et al., *Phys. Rev. B* **109**, 075433 (2024).
[6] G. Juska et al., *Nat. Phot* **7**, 527 (2011).
[7] R. A. Barcan et al. arXiv:2503.05400.
[8] R. A. Barcan et al. arXiv:2506.20339.