

Colloqui della Classe di Scienze

Anno Accademico 2025/2026

Sala Stemmi
Palazzo della Carovana
Scuola Normale Superiore
Piazza dei Cavalieri, 7 - PISA

29 APRIL 2026
h 3.00 p.m.

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QUANTUM TECHNOLOGIES FOR NMR IN THE LIFE SCIENCES

ABSTRACT:

Most Nuclear Magnetic Resonance (NMR), a widely employed spectroscopic technique in biology and the life sciences, finds diverse applications ranging from chemical analysis and drug discovery to medical imaging. Despite its versatility, NMR faces inherent limitations, primarily linked to its low sensitivity. This constraint stems from the weak nuclear spin polarization in thermal equilibrium, typically amounting to a few parts per million, coupled with the inefficiencies inherent to inductive NMR signal detection. I will explore strategies to overcome these limitations through the application of quantum technologies. Specifically, I will showcase how optically detected magnetic resonance, utilising color centers in diamond, provides a means for detecting NMR signals with chemical shift resolution at the nano- and microscale. However, achieving this goal requires additional considerations, and I will discuss how quantum control can facilitate nuclear spin hyperpolarization, resulting in 10,000-fold increases in NMR signals. Combined with signal processing methods, this approach holds the potential not only for metabolic NMR-profiling of single cells but also for metabolic magnetic resonance imaging in humans, with potential applications in early treatment assessment in cancer care using standard clinical MRI scanners.

