Interfacing Biomolecules with Coherent Quantum Sensors

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Quantum metrology enables some of the world's most sensitive measurements with potentially far-reaching applications in the life sciences. Although the ultrahigh sensitivity of qubit sensors has spurred the imagination of researchers, implementation in actual devices that enable monitoring cellular processes or detecting diseases still remains largely elusive. Overcoming limitations that hold back wider application of quantum technology in the life sciences, requires advances in both fundamental science and engineering. In this talk, I will discuss our research group's recent results on addressing one of these long-standing research challenges, namely, how to interface highly coherent quantum sensors with biological target systems.

My discussion will start with the development of a novel biocompatible surface functionalization architecture for highly coherent diamond crystals. I will then continue with discussing a new approach to engineering spin coherence in core-shell structured diamond particles, which can be readily chemically modified and delivered to intact biological systems. Finally, I will conclude my talk with an outlook on a novel class of protein-based qubit sensors that will overcome many of the fundamental challenges associated with current diamond-based quantum sensors. The unifying theme of these advances are the convergence of techniques from single-molecule biophysics, material science, and quantum engineering. Specific applications of the developed sensing platforms to questions in the life sciences will be discussed throughout this talk.

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