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Quantum-Enhanced Sensing

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Paola Cappellaro is Professor of Nuclear Science and Engineering at the Massachusetts Institute of Technology and a member of the Research Lab for Electronics, where she leads the Quantum Engineering Group. She received her Ph.D in 2006 from MIT and she then joined Harvard University as a postdoctoral associate in the Institute for Theoretical Atomic, Molecular and Optical Physics (ITAMP), before going back to MIT as a faculty in 2009.

Prof. Cappellaro is an expert in NMR, ESR, coherent control and quantum information science. She is a specialist in spin-based quantum information processing and precision measurements in the solid state. With collaborators, she developed the concept and first demonstrations of NV-diamond magnetometers. Cappellaro's major contributions have been in developing control techniques for nuclear and electronic spin qubits, including NV-diamond, inspired by NMR techniques and quantum information ideas. The goal is the realization of practical quantum nano-devices, such as sensors and simulators, more powerful than their classical counterparts, as well as the acquisition of a deeper knowledge of quantum systems and their environment. Her work has been recently recognized by the Young Investigator Award from the Air Force Office of Scientific Research and a Merckator Fellowship.

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Quantum sensors, such as the Nitrogen Vacancy color center in diamond, exploit the strong sensitivity of quantum systems to external disturbances to measure various signals in their environment with high precision. These quantum sensors have the potential to be a revolutionary tool in material science, quantum information processing, and bioimaging. However, the same strong coupling to the environment also limits their sensitivity due to its decohering effects. Error correction strategies, including quantum error correction codes, robust many-body quantum phases, and dynamical decoupling, can help in fighting decoherence, but they incur the risk of also canceling the coupling to the signal to be measured. Here I will show recent advances in tackling this challenge, including exploiting and improving control, that achieve an advantageous compromise between noise and signal cancellation. These strategies can not only improve the sensitivity of quantum sensor, but also yield new applications, via the transduction of biological signals of interest into quantum perturbations.

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How "Quantum 2.0" Sensors Can Leverage "Quantum 1.0" Semiconductor Manufacturing
Dirk Englund

Associate Professor of Electrical Engineering and Computer Science, [MIT Department of Electrical Engineering and Computer Science](#)



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Dirk Englund received his BS in Physics from Caltech in 2002. After a Fulbright fellowship at T.U. Eindhoven, he completed an MS in Electrical Engineering and a PhD in Applied Physics at Stanford University in 2008. After a postdoctoral fellowship at Harvard University, he joined Columbia University as Assistant Professor of E.E. and of Applied Physics. He joined the MIT EECS faculty in 2013. Recent recognitions include the 2011 PECASE, the 2011 Sloan Fellowship in Physics, the 2012 DARPA Young Faculty Award, the 2017 ACS Photonics Young Investigator Award, and the OSA's 2017 Adolph Lomb Medal, a Bose Research Fellowship in 2018, and a 2020 Humboldt Research Fellowship.

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The world of quantum mechanics holds enormous potential to address unsolved problems in communications, computation, and precision measurements. Efforts are underway across the globe to develop such technologies in various physical systems, including atoms, superconductors, and topological states of matter. The Englund group pursues experimental and theoretical research towards quantum technologies using photons and semiconductor spins, combining techniques from atomic physics, optoelectronics, and modern nanofabrication.

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MIT Connected Startup Presentations

Seabron Adamson

[QDTI](#)

Vikas Anant

Founder and CEO

[Photon Spot](#)

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Closing Remarks