OIST SEMINAR

Hosted By Quantum Dynamics Unit

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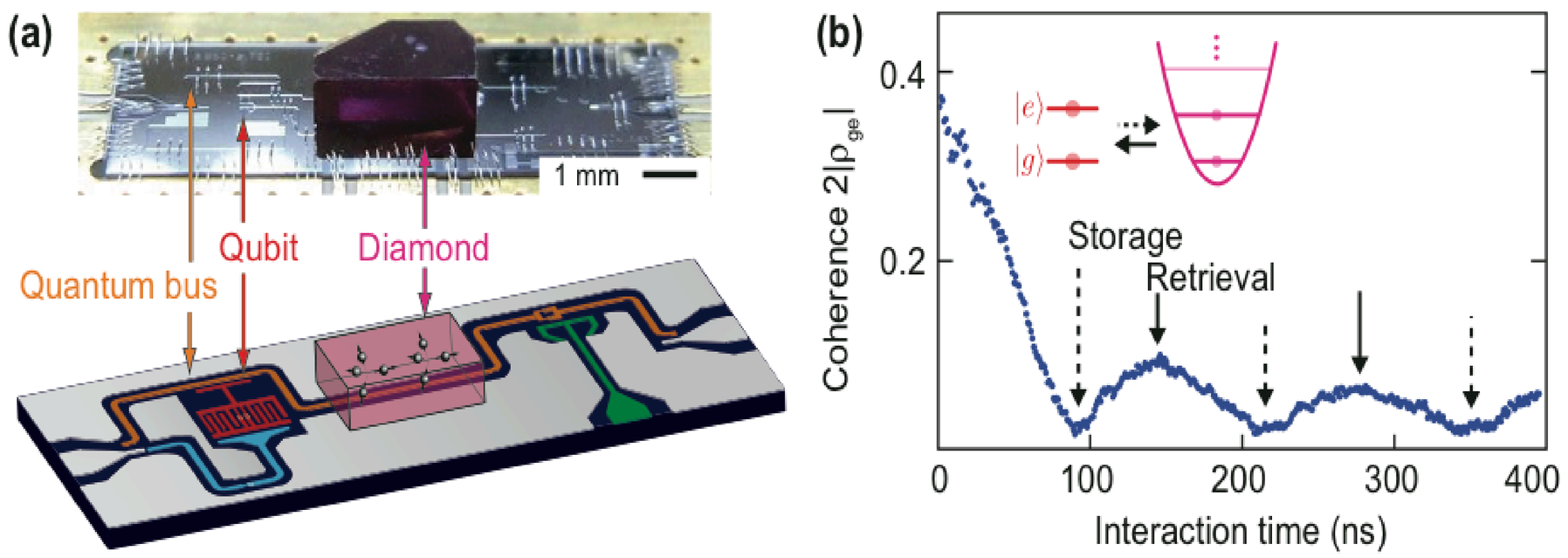
Date and Time: Tuesday, Oct 13th,15:00-16:00

Venue: Meeting Room D015, Level D, Lab1

“Hybrid Quantum Systems with Superconductors and Spins”

Abstract:
We report the experimental realization of a hybrid quantum circuit combining a superconducting qubit and an ensemble of electronic spins (Fig. a). The qubit, of the transmon type, is coherently coupled to the spin ensemble consisting of nitrogen-vacancy (NV) centers in a diamond crystal via a frequency-tunable superconducting resonator acting as a quantum bus [1,2]. Using this circuit, we prepare arbitrary superpositions of the qubit states that we store into collective excitations of the spin ensemble and retrieve back into the qubit later on (Fig. b) [3]. These results constitute a first proof of concept of spin-ensemble based quantum memory for superconducting qubits.

We also report a state-of-the-art magnetic resonance spectrometer at millikelvin temperature based on the superconducting quantum circuit technologies, i.e., using a Josephson parametric amplifier [4], where 5000 spins can be detected with a signal-to-noise of 1 in a single Hahn-echo sequence. Using the same setup we also observed spontaneous emission of spins for the first time.



(a) Photo (top) and schematic (bottom) of the hybrid quantum circuit. A transmon qubit (red) is coupled to an ensemble of NV centres electron spins (pink) via a frequency tunable quantum bus resonator (orange). (b) Modulus of the off-diagonal element r_{ge} of the qubit density matrix as a function of interaction time with the spin ensemble.
The oscillations show that the quantum coherence, which is initially prepared in the qubit, is stored/retrieved into/from the spin ensemble.

[1] Y. Kubo et al., Phys. Rev. Lett., **105**, 140502 (2010).
[2] Y. Kubo et al., Phys. Rev. A, **85**, 012333 (2012).
[3] Y. Kubo et al., Phys. Rev. Lett., **107**, 220501 (2011).
[4] A. Bienfait et al., to appear in Nat. Nanotech.