Experimental Progress on Fullerene Qubits

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The endohedral fullerenes P@C_{60} and N@C_{60} are simple, well-defined quantum systems that can be used as qubits. There are only few sources of decoherence, all identified, even in solid-state arrangements. As described elsewhere, the new ROSES project aims to develop single-spin detection as needed for scalable solid-state quantum computing. Here, we report on recent experimental advances in two more fundamental categories.

(i) from single molecules to molecular registers

- scale-up of the production and purification methods for N@C_{60}
- first complete purification of N@C_{60} by recycling-HPLC
- orientation of endohedral fullerenes in a liquid-crystalline matrix
- synthesis of N@C_{60}-C_{60} dimer molecules as a precursor for two-qubit registers
- chemical modification of N@C_{60} as a building block for molecular spin chains

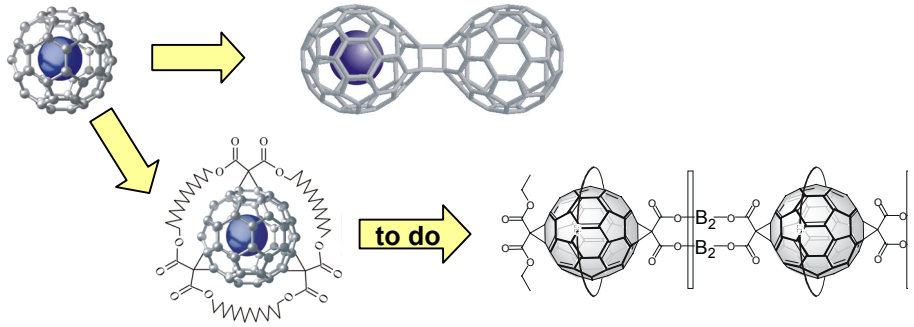

Fig. 1. N@C_{60} and some of its chemical modifications. *Top*: N@$(C_{60})_2$ dimer molecules can be produced with very small amounts of material and will soon be produced with "double filling" as two-qubit molecules. *Bottom*: a Saturn-shaped adduct has been synthesized and will be used in the future to build linear chains of endohedral fullerenes.

(ii) ensemble-type quantum computing at different temperatures

- full characterization of the spin-qubit properties relevant for quantum computing
- identification of relaxation mechanisms and dominant decoherence channels
- demonstration of ~ 50 Rabi oscillations at room temperature (see Fig.2)
- demonstration of single-shot measurements of Rabi oscillations at T = 10 K
- transition-specific Rabi frequencies of the S = 3/2 system for internal 2-qubit encoding

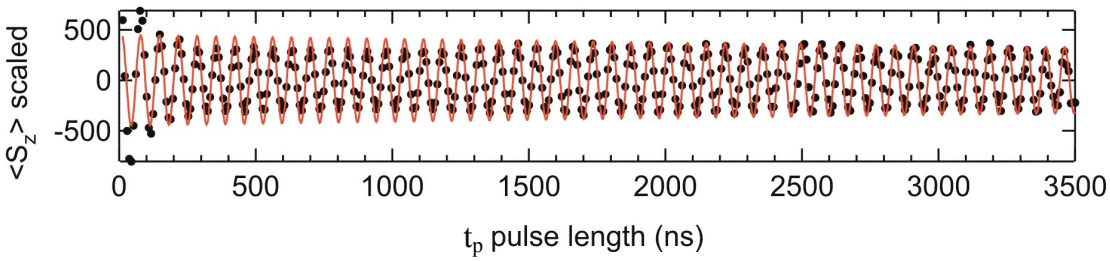

Fig. 2. Rabi oscillations for a N@C_{60} qubit ensemble at room temperature. The data (black dots) have been scaled by exp(t_p/1.1µs) to correct for relaxation due to inhomogeneities of the ensemble. The homogeneous phase coherence time for this sample is T_2 ~ 13 µs at room temperature. The solid red curve is a fit with a cosine function.