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Molecule-made electron spin pair executes quantum gate

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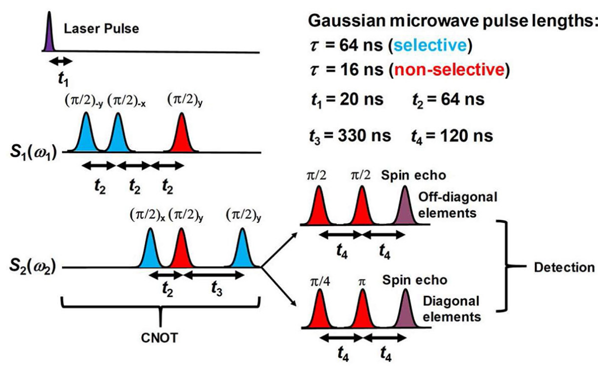
Donor-chromophore-acceptor molecule generates an electron spin pair that can run a controlled-NOT gate, a critical step on the path to realizing quantum computing.



The realization of quantum computing could revolutionize information processing. An essential benchmark along the way is achieving a controlled-NOT (CNOT) gate, a circuit element required for processing information encoded in qubits.

Nelson et al. executed a CNOT gate with high fidelity using a molecule's fast electron transfer to produce a pair of electron spins, which can serve as qubits. The molecule they employed is a chemically synthesized, covalent donor-chromophore-acceptor molecule. The donor is tetrathiofulvalene (TTF), the chromophore is 8-aminonapthalene-1,8-dicarboximide (ANI), and the acceptor is pyromellitimide (PI).

The authors excited ANI with a laser to form a $TTF^{\cdot+}$-ANI-$PI^{\cdot-}$ electron spin pair. These electron spins existed in the initial quantum state long enough for the authors to execute a CNOT gate by applying microwave pulses in a specific sequence.

Executing this CNOT gate is an important step toward developing a complete set of universal gates for quantum computing. The results also suggest that researchers could chemically synthesize molecular structures capable of carrying out even more complex quantum computing operations using electron spins.

"This work shows that molecular systems can be tailored through chemical synthesis to carry out operations that are key to quantum information science," said author Michael Wasielewski.

Next, the authors will attempt to increase the time over which information can be preserved in this molecular system to potentially allow multiple quantum gate operations to run.

Source: "CNOT gate operation on a photogenerated molecular electron spin-qubit pair," by Jordan N. Nelson, Jinyuan Zhang, Jiawang Zhou, Brandon K. Rugg, Matthew D. Krzyaniak, and Michael R. Wasielewski, *Journal of Chemical Physics* (2019). The article can be accessed at https://doi.org/10.1063/1.5128132.