Coherence in spin chain: a new route for quantum computation and communication.

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Coherence of electron spin has attracted a great interest for the last decade due to its potential application as quantum bits i.e. elementary piece of a quantum computer. Usually, electron spin qubits are made of paramagnetic impurities [1,2], which loose they coherence because of the environment interactions (spin bath, phonon bath…) .

Hereby we will present a completely new concept: in strongly correlated Heisenberg spin chain, the isotropic exchange protects the loss of quantum memory. A non magnetic defect polarize the surrounding spins and create a quantum soliton of total spin S=1/2. Since the soliton belongs to the chain it is protected from the environment by the exchange interaction. Moreover it has been proved theoretically that two qubits belonging to the same spin chain are by nature entangled (necessary condition for quantum communication). However up to now no observation of quantum coherence in such a system has been reported.

We will show the first observation of quantum coherence in electron spin solitons in the organic chain $(TMTTF)_2PF_6$.[3]. This result paves the way for the implementation of a different type of quantum computer.

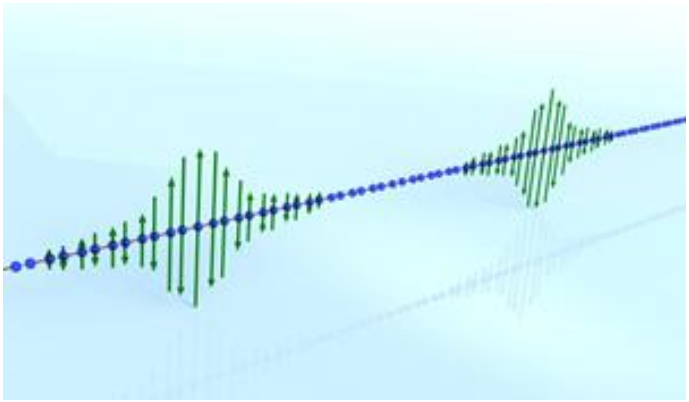

Figure 1 : Schematic representation of two sol-qubits connected by the spin chain

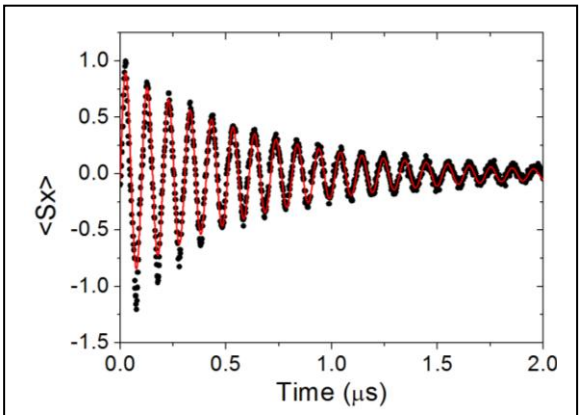

Figure 2 : Rabi oscillations of a soliton-qubit in $(TMTTF)_2PF_6$

[1] Bertaina S. et al. *Nature Nanotechnology***2**, 39 - 42 (2007)
[2] Bertaina S. et al.*Nature***453**, 203-208 (2008)
[3] Bertaina S. et al. *Phys. Rev. B***90** 060404 (2014)

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Fields of Research

Electron spin qubit, electron paramagnetic resonance, magnetism, strongly correlated electron

Publications

1. Shim J., Bertaina S., et al., *Physical Review Letters***109**, 050401 (2012).
2. Bertaina S.,et al. *Physical Review Letters***103**, 226402 (2009)
3. Bertaina S., et al. *Physical Review Letters* **102**, 050501 (2009)
4. Bertaina S., et al. *Nature***453,** 203-208 (2008)
5. Bertaina S., et al.*Nature Nanotechnology***2**, 39 - 42 (2007)