YIQIS
2020

Contribution ID: **4**

Type: **Oral**

Semiconductor qubits based on hole spins in CMOS devices and edge-states in Hall interferometers

Wednesday, 30 September 2020 16:30 (15 minutes)

Among the possible frameworks to encode the quantum bit, semiconductor-based implementations possibly present the highest potential in terms of scalability and compatibility with current nanoelectronics industry. In this talk, I will outline two different platforms for the realization of the qubit in semiconductor devices, and present the numerical approach we adopted for their characterization in full-scale simulations. The first approach, pursued within the recently started IQubits EU project [1], focuses on the use and engineering of fabricated CMOS devices to implement hole/electron spin qubits. The experimental characterization of a 22-nm FDSOI MOSFETs [2] has proved the formation of a double hole/electron quantum dot in the Si/SiGe channel, which potentially enables the monolithic integration of the control and readout circuitry on the same die [3]. The hole states are controlled by the top and back gates, while the spin is manipulated by electric-dipole spin resonance. Within a multiscale approach, we compute the single-hole states by diagonalizing the $k\cdot p$ Luttinger-Kohn Hamiltonian, starting from a realistic confining potential, simulated by means of the "Ginestra"software [4]. Prospects for scalability are included, starting from the simulation of double quantum dot systems in Si/SiGe MOSFETS, with a particular emphasis on the effects of Coulomb interactions and correlations. The second approach exploits topologically-protected edge states in the Integer Quantum Hall regime for a flying implementation of the quantum bit, with a coherence length up to 10 micrometers [5]. The qubit propagates at the edges of a confined 2DEG, while the inter-channel scattering rotates their state. Hall interferometers implement this manipulation protocol to realize single and two-qubit operation on the fly. We present our proposal for a Hall conditional phase shifter and show its feasibility for phase rotation up to π [6]. The exact two-electron wavefunction is evolved in the full-scale 2D potential of the device, where single-charges are injected as Gaussian wavepackets of edge states. Our numerical approach involves HPC techniques to include exactly the interplay between Coulomb repulsion and the device geometry, whose tuning is crucial for logic operations.

[1] www.iqubits.eu.
[2] S. Bonen et al., IEEE Electron Device Letters, 40 127-130 (2019).
[3] M. J. Gong et al., 2019 IEEE Radio Frequency Integrated Circuits Symposium (RFIC), Boston, MA, USA, pp. 111-114 (2019).
[4] www.mdlsoft.com.
[5] P. Roulleau et al., Phys. Rev. Lett. 100, 126802 (2008); E Bocquillon et al., Science 339 6123 (2013).
[6] L. Bellentani, G. Forghieri, P. Bordone and A. Bertoni, Phys. Rev. B 102, 035417 (2020).

Presenter: BELLENTANI , Laura (S3 CNR-Nano)

Session Classification: Invited