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How to study quantum physics with silicon nano-structures

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Abstract

On-demand transfer of single electrons via semiconductor nano-structures has attracted great interest in the context of quantum technologies since the early 90s. This technique, initially developed to enable a quantum realisation of the unit ampere, more recently has proved to be key for other emerging applications, including the possibility to create single-photon sources [1].

At present, the best certified accuracy of the charge transfer has been achieved with GaAs quantum dot (QD)-based pumps [2]. However, in order to optimally operate these devices, demanding experimental conditions are required, such as very large perpendicular magnetic field, millikelvin temperature, and, in some case, specially tailored waveform of the driving signal [3]. In this context, Si implementations promise to significantly simplify these operation requirements in light of the mature single dopant [4] and other metal-oxide-semiconductor (MOS) [5-8] technologies by offering good control of the electrostatic confinement.

After having discussed some of our recent published results [4,5], I will introduce a new model used to describe the behaviours observed in our single dopant devices [4,6]. Furthermore, I will show how, by improving upon some previous [5] silicon QD device design, we have achieved tighter electrostatic confinement and charging energies in excess of 30 meV in the few-electron regime also for MOS QDs, hence allowing some very high frequency of pumping operation [8].

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[4] G. C. T. et al., NJP 16 (6), 063036 (2014)
[5] A. Rossi,..., G. C. T., et al., Nano Lett. 14, 3405 (2014).
[6] J. van der Heijden, G. C. T. et al., https://arxiv.org/abs/1607.08696 (2016)
[7] G. Yamahata et al., Nature Comm. 5, 5038 (2012).
[8] A. Rossi,..., G. C. T., in preparation.

The speaker

After graduating with a M. Sc. in Solid State Physics at the University of Rome “La Sapienza” and successively with a PhD Degree at the University of Melbourne, Dr. Giuseppe Tettamanzi moved to the Kavli Institute of Nano-Science in Delft (NL) as FOM research fellow within the Photronic Group, where he held a ARC DECRA fellowship from 2012 and 2014. Since middle 2013 G. T. is a Senior Lecturer in the School of Physics at the UNSW, where he established a research activity in Silicon-based Quantum Metrology, on novel hybrid Superconductor-Semiconductor Single Atom Transistor devices and on two-dimentional transistor devices.