MASTER PHYSIQUE ET APPLICATIONS

Master 2 Dispositifs Quantiques

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Internship offer

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Theoretical study of thermoelectric properties beyond the linear response of Single Electron Transistor

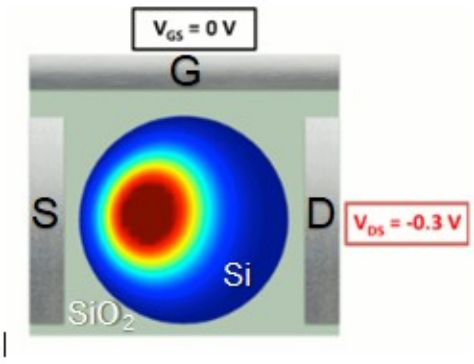

Fig. 1: Schema of a Single electron transistor (SET) with a map of electron density for one electron in the QD.

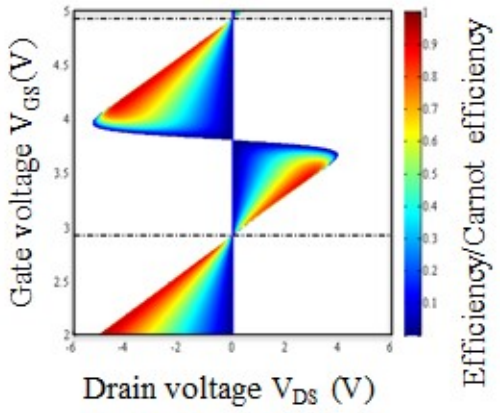

Fig. 2: Cartography of normalized conversion efficiency.

Scientific project:

Specific properties of nanostructures have generated a recent revival of interest in thermoelectric devices [1]. Thanks to their delta-like density of states, devices based on quantum dots are expected to exhibit high Seebeck coefficient, nearly zero electronic thermal conductance and ultra-low phononic thermal conductance if embedded in an oxide matrix [2]. Due to single-electron tunneling across discrete levels in the Quantum Dot (QD), such devices are likely to behave as quasi-ideal energy filters giving rise to incomparable thermoelectric properties, i.e. with an efficiency very close to the ideal Carnot efficiency. An internship position dedicated to the simulation of such device is available in the COMputational electronICS group belonging to Center of Nanosciences and Nanostructures.

[1] Zhi-Gang Chen, Guang Han, Lei Yang, Lina Cheng, Jin Zou, In Progress in Natural Science: Materials International, Volume 22, Issue 6, Pages 535-549 (2012) https://doi.org/10.1016/j.pnsc.2012.11.011.
[2] Mahan, G. & Sofo, J. The best thermoelectric. Proc. Natl. Acad. Sci. 93, 7436–7439 (1996). DOI 10.1073/pnas.93.15.7436
[3] Talbo, V., Galdin-Retailleau, S., Valentin, A. & Dollfus, P. IEEE Transactions on Electron Devices 58, 3286–3293 (2011). DOI 10.1109/TED.2011.2161611
[4] Vincent Talbo, Jérome Saint-Martin, Sylvie Retailleau, and Philippe Dollfus, Scientific Reports, 7, 14783 (2017). https://www.nature.com/articles/s41598-017-14009-4
[5] G. Benenti, G. Casati, K. Saito, et R. S. Whitney, Physics Reports, vol. 694, p. 1-124 (2017).

Methods and techniques:

By using our homemade code consisting in a 3D Poisson-Schrödinger solver and the resolution of the Master equation [3,4], the thermoelectric properties of a Si-quantum dot-based single-electron transistor operating in sequential tunneling regime are investigated in terms of thermoelectric figure of merit ZT, efficiency and power (cf. Fig 1 and Fig 2.). By taking into account the phonon-induced collisional broadening of energy levels in the quantum dot, **both heat and electrical currents are computed in a voltage and temperature ranges beyond the linear response** [5].

Possibility to go on with a PhD ? YES

Envisaged fellowship ?