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# Quantum Physics of Nanostructures - Problem Set 5

*Winter term 2014/2015*

**Due date:** The problem set will be discussed Wednesday, 07.01.2015.

**Internet:** Course information and problem sets are available online at http://www.uni-leipzig.de/~stp/QP_of_Nanostructures_WS1415.html.

## 10. Conductance-Peak Shape

*5+5+5+5 Points*

In this problem, you will derive a formula for the peak shape of the conductance $G$ of a single electron transistor (SET) at finite temperature $T$.

(a) Determine the finite-temperature rates $\Gamma_i(T)$ corresponding to the contributing single electron transfer processes $i \in \{FL, TL, FR, TR\}$. Use the following result:

$$\Gamma_i(T) = \frac{G}{e^2} \frac{\Delta E_i}{\exp(\Delta E_i / k_B T) - 1},$$

where $\Delta E_i$ refers to the energy difference corresponding to a given single electron transfer.

(b) Repeat the analysis of the SET based on the master equation governing the probabilities $p_N$ of having a charge state with $N$ electrons at the central island of the SET. To this end, derive a stationary solution, and express the current $I$ through the rates $\Gamma_i(T)$.

(c) Focus on a region in the $V - q$ plane appropriate for single electron transport (assume a symmetric SET $C_R = C_L$ with asymmetric bias), and determine the temperature and voltage dependence of the current $I$ through the transistor.

(d) To obtain the peak shape, expand your result for the current $I$ for small bias voltage. Determine the position of the conductance peak, and derive a formula determining its shape. Discuss the temperature dependence of the peak shape.

**Merry christmas & a happy new year!**

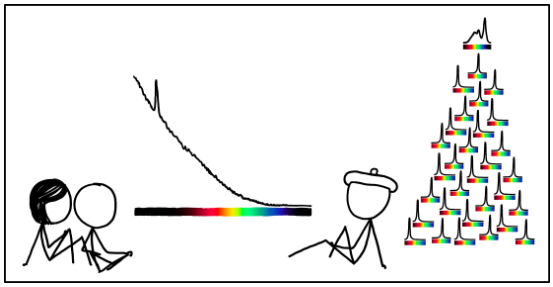

Figure 1: xkcd comic #1308, 'Christmas lights', see also this one http://xkcd.com/643/.