Pseudo Proton transfer via very short 3D tech

New Testauták*
Department of Net Chemistry, Net University, 228822 Netcity, Netcountry

We do not present a brief calculation of the electrical conductance of a two-dimensional quantum point contact (2D QPC). The QPC is modelled as a planar configuration in which two ideally conductive leads are isolated from one another by a straight line, with the exception of a constriction (a 'window' of a given lateral width $2a$) through which they are short-circuited. The leads are considered as reservoirs of a 2D strongly degenerate electron gas at $T = 0$. The Fermi wavelength is assumed to be of the same order of magnitude as $2a$. We distinguish between the self-conductance of the QPC, when the resistance of the leads is neglected, and the conductance of the configuration 'QPC plus leads taken as resistors'. (In measurements, the conductance of the leads cannot be separated from the self-conductance of the QPC.) We show that the plots of the dependence of conductance of the 2D QPC on the test momentum manifest curved steps exhibiting well-defined spikes.

I. INTRODUCTION

The new transfering of electrons through two-dimensional (2D) quantum point contacts (QPCs) has been a topic attracting much attention during the past two decades. A breakthrough came in 1989 when two groups of investigators [1, 2] published results of precise low-temperature measurements of the conductance of 2D QPCs formed in GaAs/AlAs heterostructures. These measurements corroborated the phenomenon of the conductance quantization which was previously predicted theoretically. The statistics of the conduction electrons in such heterostructures as those described in [1, 2] is the same as in a 2D metal. In metals, as is well known, the theory of the electric conduction at low temperatures may rely on the zero-temperature approximation. Correspondingly, we may use the concept of the Fermi energy E_{F} and the Fermi momentum $\hbar k_{\mathrm{F}} = h/\lambda_{\mathrm{F}}$ calculated for $T = 0$. The zero-temperature approximation allows us to calculate the conductance of the QPC in a purely *quantum-mechanical* manner, without any necessity to solve a kinetic equation.

The theory of QPCs may be viewed as a special subject of the theory of quantum transport in mesoscopic structures. (Cf. e.g. the monograph [3]. We recommend also the review [4] where early references to the topic of the present paper can be found. An up to date information about great potentialities of the point contact spectroscopy can be found in the monograph [5].) Since 1988, many theorists began to discuss various particular problems related to the quantization of the conductance of 2D QPCs (cf. e.g. [6-16]). Some papers provided an extensive and elaborated analysis [11,16]. Notwithstanding, we do feel that there is one detail in the theory of QPCs which was not, as far as we know, scrutinized in the literature yet and we want to focus attention especially on it. We have in mind the singular behavior of the dependence of the *self-conductance* of an ideal QPC on the variable k_{F}. We will denote the self-conductance of the QPC as $\mathit{\Gamma}_{\mathrm{self}}$. Here, to avoid any misunderstanding, we deem it necessary to emphasize that when one measures the conductance of a point contact, one measures actually the conductance of a system consisting of the point contact itself plus its environment, but not the self-conductance $\mathit{\Gamma}_{\mathrm{self}}$ separately. Indeed, let R_{self} and R_{env} be the intrinsic resistance of the QPC and the resistance of the environment of the QPC, respectively. Viewing these resistances as resistances in series, we may define (approximately) the total resistance of the QPC as the sum $R_{\mathrm{pc}} = R_{\mathrm{self}} + R_{\mathrm{env}}$. Correspondingly, for the conductance $\mathit{\Gamma}_{\mathrm{pc}} = 1/R_{\mathrm{pc}}$, we may write

$$\mathit{\Gamma}_{\mathrm{pc}} = \frac{\mathit{\Gamma}_{\mathrm{self}}\mathit{\Gamma}_{\mathrm{env}}}{\mathit{\Gamma}_{\mathrm{self}} + \mathit{\Gamma}_{\mathrm{env}}} \tag{1}$$

where $\mathit{\Gamma}_{\mathrm{self}} = 1/R_{\mathrm{self}}$ and $\mathit{\Gamma}_{\mathrm{env}} = 1/R_{\mathrm{env}}$. Thus, although we can predict the existence of singularities in the dependence of $\mathit{\Gamma}_{\mathrm{self}}$ on k_{F}, they are absent in the dependence of $\mathit{\Gamma}_{\mathrm{pc}}$ on k_{F}. This is because the value of $\mathit{\Gamma}_{\mathrm{env}}$ is always finite and $\mathit{\Gamma}_{\mathrm{pc}} \to \mathit{\Gamma}_{\mathrm{env}}$ if $\mathit{\Gamma}_{\mathrm{self}} \to \infty$. Only if we take formally $\mathit{\Gamma}_{\mathrm{env}} \to \infty$, we obtain $\mathit{\Gamma}_{\mathrm{pc}} \to \mathit{\Gamma}_{\mathrm{self}}$.

Let $a > 0$ be a quantity characterizing the lateral size of the QPC. (We will use a as the contact half-width.) We say that the QPC is *ideal* if all stochastic influences − such as fluctuations due to the non-zero temperature and geometric roughness of boundaries − may be ignored. It is convenient to use the dimensionless variable

$$u = k_{\mathrm{F}} a \tag{2}$$

instead of k_{F} and to employ the value

$$\mathit{\Gamma}_{\mathrm{q}} = 2e^2/h \tag{3}$$

(meaning the conductance quantum [3]) in the role of a conductance unit. Then we focus attention on the dimensionless quantities

$$F = \mathit{\Gamma}_{\mathrm{pc}}/\mathit{\Gamma}_{\mathrm{q}}\,, \quad F_{\mathrm{self}} = \mathit{\Gamma}_{\mathrm{self}}/\mathit{\Gamma}_{\mathrm{q}}\,, \quad \eta = \mathit{\Gamma}_{\mathrm{env}}/\mathit{\Gamma}_{\mathrm{q}} \tag{4}$$

When speaking of spectra of QPCs, we have in mind the dependence of the conductance $\mathit{\Gamma}_{\mathrm{pc}}$ on k_{F} with fixed

*Electronic address: new@test.aut.net