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# Tunneling Enhancement through a Barrier Surrounded by a Mesoscopic Cavity

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## INTRODUCTION

We have studied the effect of a potential barrier included in a mesoscopic cavity, i.e. a region much wider than the Fermi wavelength of the electrons and delimited by constrictions that are of the order of such a wavelength. Mesoscopic cavities are usually obtained by means of two quantum point contacts that define constrictions with a width of a few tens or hundreds of nanometers in a mesa that is several microns wide [1]. Several interesting results have been obtained for the noise and conductance behavior of such structures [2], [3], [4].

Here we focus on an intriguing property of a cavity containing a relatively opaque (compared to the constrictions defining the cavity) barrier. In particular, we have observed that the overall conductance of the cavity is strongly dependent on the position of the barrier, with a maximum corresponding to the situation with the barrier exactly in the middle of the cavity. The most striking feature is that in this condition the overall transmission coefficient is much larger than that which would be associated with the isolated barrier.

## MODEL AND NUMERICAL RESULTS

We adopt a numerical approach based on the recursive Green's function technique and consider a mesoscopic cavity, sketched in Fig. 1, which is defined by hard walls, with a length of 5 $\mu$m. Different values are considered for the width of the cavity and of the constrictions. In Fig. 2 we report the dependence of the overall transmission of the structure as a function of the position of an 11 nm thick and 40 meV high potential barrier in a cavity that is 500 nm wide and delimited by 50 nm constrictions. The transmission of the barrier alone at the value of the energy being considered (9.03 meV) is 0.195: it is apparent that when the barrier is located exactly in the middle of the cavity, the transmission reaches a value (0.6) well above that for the cavity, thus exhibiting quite significant a tunneling enhancement. Enhanced tunneling is observed also for positions corresponding to 1/4 and 3/4 of the cavity and for other intermediate positions. In Fig. 3 we report data for a structure identical to the one just described, but with the right constriction 70 nm wide: constriction asymmetry does not destroy the effect. The tunneling enhancement gains in strength as the cavity is made wider, as shown in Fig. 4, where the transmission dependence is reported for a cavity width of 4 $\mu$m, and a 15 nm thick barrier (with a transmission factor 0.244). In this case only a very strong peak for the barrier in the cavity center survives, while the others disappear.

This is not a simple resonance effect, because it can be observed over a large range of energies, as shown in Fig. 5, where the transmission of a cavity with a barrier in the middle is plotted (thick curve) as a function of the Fermi energy. We propose a preliminary explanation based on the fact that odd longitudinal modes in the cavity are not significantly affected by the presence of a barrier in the middle, where they have a node. The modes in the constriction couple to such modes in the cavity, which can propagate freely and reach the exit constriction.

## REFERENCES

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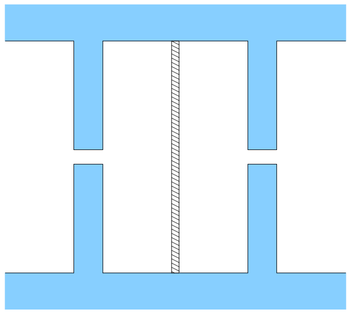

Fig. 1. Sketch of the cavity with the potential barrier.

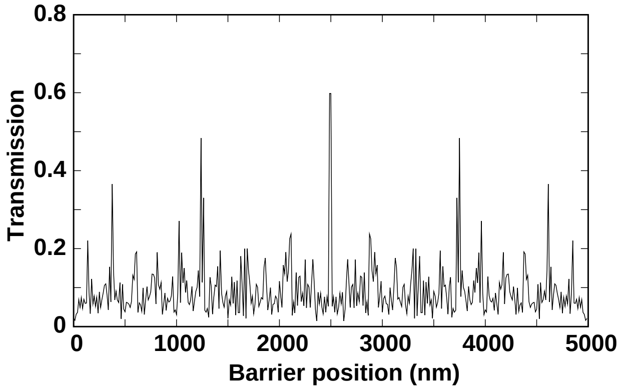


Fig. 2. Transmission vs. barrier position for a symmetric 500 nm wide cavity.

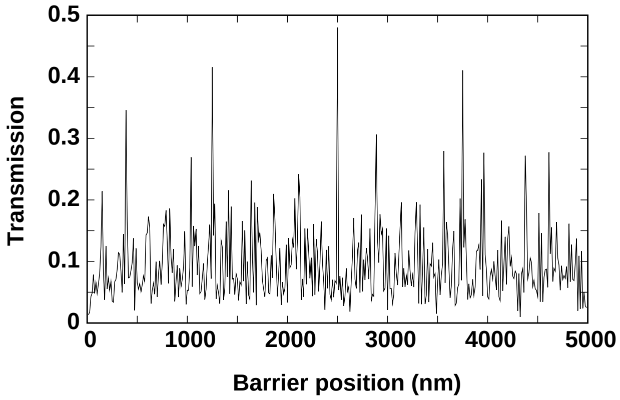


Fig. 3. Transmission vs. barrier position for an asymmetric 500 nm wide cavity.

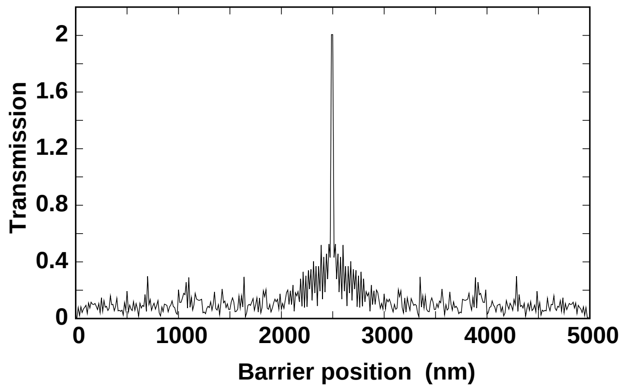


Fig. 4. Transmission vs. barrier position for a 4000 nm wide cavity.

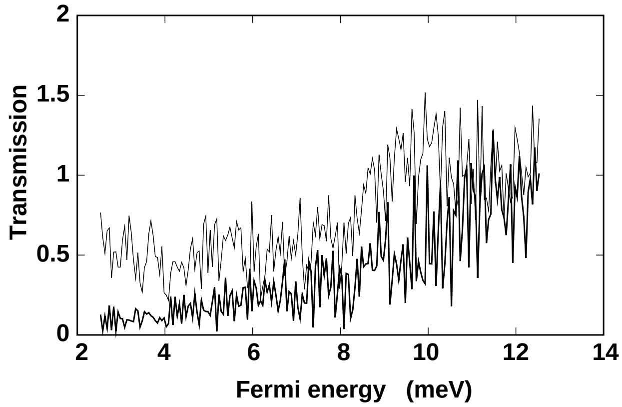


Fig. 5. Transmission vs. Fermi energy for a cavity with (thick line) and without (thin line) barrier.