AIP | Applied Physics Letters

Comment on “Strong wave-vector filtering and nearly 100% spin polarization through resonant tunneling antisymmetrical magnetic structure” [Appl. Phys. Lett. 81, 691 (2002)]

G. Papp and F. M. Peeters

Citation: Applied Physics Letters **82**, 3570 (2003); doi: 10.1063/1.1577821
View online: http://dx.doi.org/10.1063/1.1577821
View Table of Contents: http://scitation.aip.org/content/aip/journal/apl/82/20?ver=pdfcov
Published by the AIP Publishing

APPLIED PHYSICS LETTERS VOLUME 82, NUMBER 20 19 MAY 2003

Comment on "Strong wave-vector filtering and nearly 100% spin polarization through resonant tunneling antisymmetrical magnetic structure" [Appl. Phys. Lett. 81, 691 (2002)]

G. Papp[a] and F. M. Peeters[b]
Departement Natuurkunde, Universiteit Antwerpen (UIA), Universiteitsplein 1, B-2610 Antwerpen, Belgium

(Received 18 November 2002; accepted 8 April 2003)

[DOI: 10.1063/1.1577821]

In a recent letter, Xu and Shi[1] proposed theoretically to realize spin polarization in a two-dimensional electron gas (2DEG) by using antisymmetrical double-barrier magnetic structures. This is a generalization of our previous[2] work on tunneling through a single double-barrier magnetic structure. Using the single particle effective mass approximation, they calculated the transmission probability, the spin polarization P, the conductance G, and the relative spin conductance excess $G_{\uparrow\downarrow}=(G_{\uparrow}-G_{\downarrow})/(G_{\uparrow}+G_{\downarrow})$. Here, $G_{\uparrow}$ and $G_{\downarrow}$ are the conductance with electron spin up and down, respectively. The authors found that beyond the second resonant energy [see Figs. 3(a) and 3(b) of Ref. 1], the polarization oscillates very rapidly, in an almost random way, between $+1$ and -1 with the incident electron energy. We found that this behavior is wrong and is an artifact of their numerical procedure, which can be traced back to a problem of insufficient accuracy. The resonance peaks over which one has to integrate are extremely sharp [see the inset of Fig. 1(b)], and if the integration steps are not sufficiently small, the results of Ref. 1 are recovered. However, for sufficiently small integration steps, the results as shown in Figs. 1(a) and 1(b) do not exhibit any wild oscillations beyond the Fermi energy $E_{\mathrm{F}}/E_0\approx 3.2$ (GaAs), 3.4 (InAs). For Fermi energies that are larger than these resonant energies, the relative spin conductance excess remains negative. The reason is that for this energy interval, the transmission of $\sigma=-1$ dominates [see the inset of Fig. 1(b)].

Furthermore, we generalized these results to nonzero temperature: $G(\mu)=\int d\epsilon G(\epsilon)(-\partial f_0/\partial\epsilon)$, where $f_0=\{\exp[(\epsilon-\mu)/k_{\mathrm{B}}T]+1\}^{-1}$. Notice that for even small thermal fluctuations, the sharp peak in the conductance disappears (see inset of Fig. 1), and consequently any interesting effects in the relative spin conductance excess are destroyed [dashed line in Fig. 1(a)]. For InAs, larger temperatures are needed to smooth out the spin polarization [see dashed curve in Fig. 1(b)].

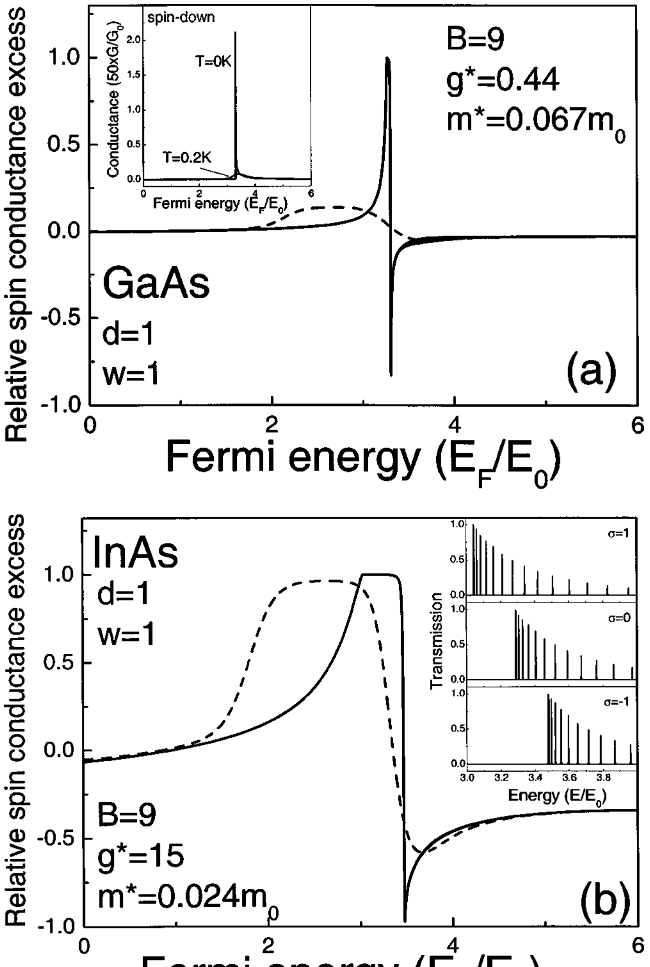

FIG. 1. The relative spin conductance excess vs the Fermi energy for (a) GaAs and (b) InAs ($T=0$ K solid curve, $T=0.2$ K dashed curve). All parameters are taken the same as those in Ref. 1. The inset in (a) shows the conductance vs the Fermi energy for electrons with spin down, and the inset in (b) is the transmission probability as function of energy.

Part of this work was supported by the Flemish Science Foundation and the Flemish-Hungarian Bilateral Cultural exchange program.

---

[a] Permanent address: Department of Theoretical Physics, University of Szeged, Aradi vtk. tere 1, Szeged, Hungary, and Institute of Physics, University of West Hungary, Bajcsy Zs. út 5–7, Sopron, Hungary; electronic mail: pgy@physx.u-szeged.hu

[b] Electronic mail: francois.peeters@ua.ac.be

[1] H. Z. Xu and Z. Shi, Appl. Phys. Lett. **81**, 691 (2002).
[2] G. Papp and F. M. Peeters, Appl. Phys. Lett. **78**, 2184 (2001); **79**, 3198 (2001).