Calculation of d.c. current in a non-interacting resonant level model

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Quantum transport in resonant-tunneling diode (RTD) have been investigated by many researchers. Resonant-level model is used to analyze d.c. current of RTD [1]. The current voltage at zero-temperature $J_{dc}$ is simply obtained if the level-width and the level-shift of tunneling electrons are energy independent.

$$J_{dc}(V) = \frac{e}{h} \frac{2 \Gamma}{1} \sum_{k} \frac{V_{k}}{e^{-\epsilon_{k_{L,R}}}}$$

where, the chemical potentials $\mu_{L,R}$ and the low energy cutoff $D_{L,R}$ define the band width. The central region energy $\epsilon_{0}$ and the right chemical potential depend on the applied voltage $\mu_{R}(V) = \mu_{R} - eV$ and $\epsilon_{0}(V) = \epsilon_{0}V/2$, respectively. Among the parameters, the level width $\Gamma$ is the most effective for the d.c. current because it includes the potential of the contact. The obtained d.c. current vs applied voltage is shown in figure and the level width including the potential of the contact is important for the d.c. current.

$\Gamma(\epsilon) = 2\pi \sum_{k_{L,R}} \frac{|V_{k_{L,R}}|^{2}}{\epsilon - \epsilon_{k_{L,R}}}$

Further, we attempt to get the level width $\Gamma$ by solving self-consistent equations considering the electrochemical potentials and fermi energy in leads.

Figure 1: D.C.current vs applied voltage. Parameters are $\epsilon_{0} = 2.0, \mu_{L} = 0, \mu_{R} = -6.0, D_{L} = 2, D_{R} = -4$. The level width of the right case is 10 times wider than that of the left case.

