Kinetics of electrons in layered nanostructures.

Victor Los

Insitute for Magnetism, Kiev, Ukraine

An exact time-dependent solution for the wave function ψ(r,t) of a particle moving in the presence of an asymmetric rectangular well/barrier potential varying in one dimension is obtained by applying a novel for this problem approach using multiple scattering theory (MST) for the calculation of the space-time propagator. This approach, based on the localized at the potential jumps effective potentials responsible for transmission through and reflection from the considered rectangular potential, enables considering these processes from a particle (rather than a wave) point of view. The solution describes these quantum phenomena as a function of time (see Figure below) and is related to the fundamental issues (such as measuring time) of quantum mechanics and to the kinetic theory of nanostructures due to the fact that the considered potential can model the spin-dependent potential profile of the magnetic multilayers used in spintronics devices. It is presented in terms of integrals of elementary functions and is a sum of the forward- and backward-moving components of the wave packet. The relative contribution of these components and their interference as well as of the potential asymmetry to the probability density $|\psi(x,t)|^2$ and particle dwell time is considered and numerically visualized for narrow and broad energy (momentum) distributions of the initial Gaussian wave packet. It is shown that in the case of a broad initial wave packet, the quantum mechanical counterintuitive effect of the influence of the backward-moving components on the considered quantities (often overlooked) becomes significant. The influence of the potential asymmetry in this case can also be more pronounced.

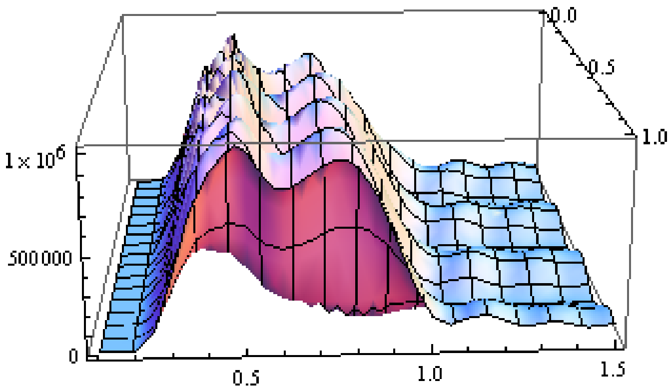

Figure 1. Probability density , $\psi(x,t)|^2$, as a function of time (t=0-1.5) inside (above) the asymmetric well (x=0-1) modeling a spacer in a metallic magnetic threelayer for a broad energy distribution of the initial wave packet.