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ABSTRACT

Electronic transport in nanostructures is investigated theoretically in the present thesis. We have made all investigation using Equation of Motion (EOM) method. The conductance for the systems investigated were calculated using Meir's extension formula for interacting system. These studies can be divided into three parts:

In first part, we study transport through T-shaped double quantum dot system. A common feature of quantum dot devices is the extreme sensitivity of the device to the surrounding electrostatic environment. The transport through a single dot device can be significantly changed by the presence of a defect in the proximity of the active device as a result of tunneling between the defect and the active device and the interactions between them. Such defects could arise naturally in the process of fabrication of the device or could be introduced deliberately in order to control the properties of the device. In this context we study analytically the effect of a dot-like defect present near a quantum dot single electron transistor which consists of a semiconductor quantum dot weakly coupled to the source and drain leads and to the gate electrode. It is found that the conductance profile is changed significantly by the quantum mechanical tunneling between the dots, interdot Coulomb interaction and energy level difference between them. The interdot tunneling and interdot interaction are dependent on the distance between the dots. We also find that even a very small strength of interdot interaction has a major influence on the transport and must be taken into account in device fabrication.

In second part, the electrical response of a single electron transistor, realized within individual metallic single walled carbon nanotubes by creating two tunnel barriers which sandwich a short section of nanotube, is theoretically investigated. The single walled carbon nanotubes connected to a very short nanotube via tunnel barrier is modelled by extended Anderson model. The conductance of the system was calculated using non-equilibrium Green's function. The amplitude of the conductance depends upon the confinement potential in short section of the nanotube which acts as a quantum dot. The conductance of such a system is sensitive to the location of van Hove singularities present in density of states of connecting carbon nanotube leads. We found that the conductance peak height decreases when the dot energy level is aligned with position of singularity in density of states of carbon nanotube lead due to the high DOS around the singularity that results in delocalization of electron over the entire dot-lead system. This information may be used for the identification of chirality of an unknown metallic single wall carbon nanotube.

In third and last part of the thesis, we investigated the behaviour of electrical transport in the coupled single wall carbon nanotube quantum dot system in parallel geometry. In this section, we study the effect of interdot Coulomb interaction, tunneling and the structure of carbon nanotube leads on conductance. We found that as the interdot tunneling coefficient increases in the presence of interdot Coulomb interaction, the height of the third peak increases while in the absence of interdot Coulomb interaction it decreases. It is due to the renormalization of the onsite Coulomb interaction by interdot interaction through the addition of electrons. The peak separation between the first and second peaks does not get affected due to the interdot Coulomb interaction while peak separation between the third and fourth peaks is larger as compared to the separation between first and second peaks because of interdot interaction. It also shows that the interdot interaction is not so important for filling up the first two electrons and it only influence the filling of third and fourth electrons. We have also investigated how the position of van Hove singularity in density of states of carbon nanotubes affects the conductance in double quantum dot parallel system.