

## Dynamic Effects on Electron Transport in Linked Metal Nanoparticles

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For the last five years, Coulomb blockade devices using chemically tailored ligand-stabilized metal nanoparticles were proposed,[1] and electron transport via single electron tunneling in an array of the metal nanoparticles has attracted attention.[2] The arrays are distinct from quantum dots formed on the substrate because the metal nanoparticles are movable, which stems from that the ligands linking the metal nanoparticles are elastic, whose elastic moduli are extremely small compared with typical metals or semiconductors.[3] Hence the array can be regarded as a lattice with the nearest neighbor interaction. Electrons are localized in the metal nanoparticles because of high resistance of the ligands, and electron tunneling between the nanoparticles provides alternate electrostatic force on the charged metal nanoparticles, which will excite collective vibrations of the array. Considering that the tunneling probability depends exponentially on the nanoparticle displacement, the nanoparticle vibrations are expected to significantly affect the electron transport, and simultaneously reflect the change in the number of electrons of the metal nanoparticles through electrostatic force on the nanoparticles. Thus the nanoparticle vibrations will be rather complex, and related electron transport is hardly inferred.

The purpose of this work is to investigate the vibrations of linked metal nanoparticles and related electron transport, illustrating gold( $\text{Au}_{55}$ ) nanoclusters, by means of a Monte Carlo method for electron tunneling and molecular dynamics for nanoparticle motion. We mainly study two linked nanoparticles, and find that the resultant nanoparticle vibrational modes comprise nanoparticle motion and electron tunneling correlated with the motion, being quite different from usual vibrational modes of linked oscillators. Then the modes depend on applied electric field for electron transport, showing hysteretic behavior in certain region of the potential. Uncorrelated tunneling infrequently occurs, causing random switching between the vibrational modes. The electron transport properties synchronize with the change of the nanoparticle vibrations, showing hysteresis and random telegraph noise of the current. These transport properties are found in a larger array of the metal nanoparticles.[4]

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