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Anomalous 0.7 Electrical Conductance Quantization in Nano-scale Constriction

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The conductance quantization in units of $G_0=2e^2/h$ through a quantum point contact (QPC) is a result of quantum mechanical adiabatic transmission of electrons through spin-degenerate non-interacting one-dimensional (1D) channels. Shortly after the discovery of this integer conductance plateau, an additional plateau was observed at around $0.7G_0$, which has been known as the 0.7 structure. Since this anomalous conductance plateau cannot be explained in a single-particle picture, theoretical explanations based on electron-electron interaction, spin effect, and others have been suggested. The spontaneous spin polarization model and the Kondo-related model are most popular among them, which were supported experimentally by Thomas et al. and Cronenwett et al., respectively. Nonetheless, no consensus has been reached about its origin yet and still contradicting experimental and theoretical results are reported. Furthermore, the 0.7 structure is not always revealed in a QPC, although the phenomenon is regarded as intrinsic properties of 1D conduction channels. In most studies, however, the absence of the 0.7 structure was simply ignored and the condition for the occurrence of this structure has not been systematically investigated. In this study, we report a new approach to the formation of the anomalous 0.7 structure by using a quantum-dot structure, which allowed us to tune to the optimal observing condition at our disposal. This tunable 0.7 structure showed characteristics that are very similar to the conventional 0.7 structure in a QPC, but with additional new features. We believe our results will shed light on clarifying the origin of the ever-controversial phenomenon.