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Bi-stability in a two-level quantum dot with attracting e-e interaction

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Abstract

By considering a current carrying two-level quantum dot(QD) with e-e attraction, we obtain the current and electron populations as functions of applied bias voltage using a self-consistent Hartree-Fock(HF) approximation and show that the system could be bi-stable and there exist hysteresis loops. Investigating the permanent polarization, we also show that the permanent polarization changes sign and interpret this as a quantum phase transition, since our system is at zero temperature.

Keywords: e-e attraction, Hartree-Fock approximation, bi-stability, hysteresis, quantum phase transition

1. Introduction

By recent developments in nanotechnology and especially nanoelectronics [1, 2], the interest and need in theoretical understanding of nano circuit elements gets stronger. Among these elements, those who would possibly show bistability are of great importance, since they could be used to manufacture nano transistors and switches. In recent years there have been a long debate about the existence of bi-stability in QDs, mostly in the presence of electron-phonon interaction. Several numerical approaches [3, 4, 5, 6, 7, 8, 9] and experimental results [10, 11, 12] confirm the appearance of this phenomenon in different QD systems, while there exist some arguments against bi-stability in some special cases [13, 14, 7].

Another interesting phenomenon that has been studied in relation to QDs is *quantum phase transition*(QPT). Such phase transitions are caused by nonthermal fluctuations and take place at zero temperature. By changing a specific control parameter, one could cause the needed fluctuations for the phase transition to occur. Such phase transitions are fully understood in Ising models and similar systems (for a full description, see Ref.[15] and references there in). In the case of QDs, phase transitions in several geometries and mostly concerning the spin degree of freedom are widely studied [16, 17, 18, 19, 20, 21, 22]. But

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