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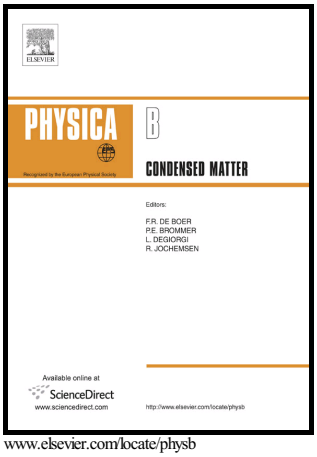

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Bi-stability in a two-level quantum dot with attracting e-e interaction

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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 bi-stability 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 non-thermal 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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