Probing the nuclear spin of a single donor in Silicon nanotransistors.

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Abstract

Detection of a single nuclear spin constitutes an outstanding problem in different fields of physics such as quantum computing or magnetic imaging. Here we show that the energy levels of a single nuclear spin can be measured by means of a tunneling current [1]. As an example, we consider electronic transport through the single donor level of a Bismuth dopant in a Silicon nanotransistor, both in the sequential and in the cotunneling regimes, which has already been experimentally demonstrated [2,3]. In the sequential regime case, the dI/dV curve yields the single electron spectral function, while in the cotunneling regime, it provides information about the electronic spin spectral function [4]. The hyperfine coupling to the nuclear spin results in a modification of the electronic spin spectral function which, in turn, could be probed by Inelastic Electron Tunneling Spectroscopy (IETS)[1,4-5], provided that the spectral resolution is high enough. We find that the hyperfine coupling opens new transport channels which can be resolved at experimentally accessible temperatures. Our simulations also evince that IETS yields information about the occupations of the nuclear spin states, paving the way towards transport-detected single nuclear spin resonance.

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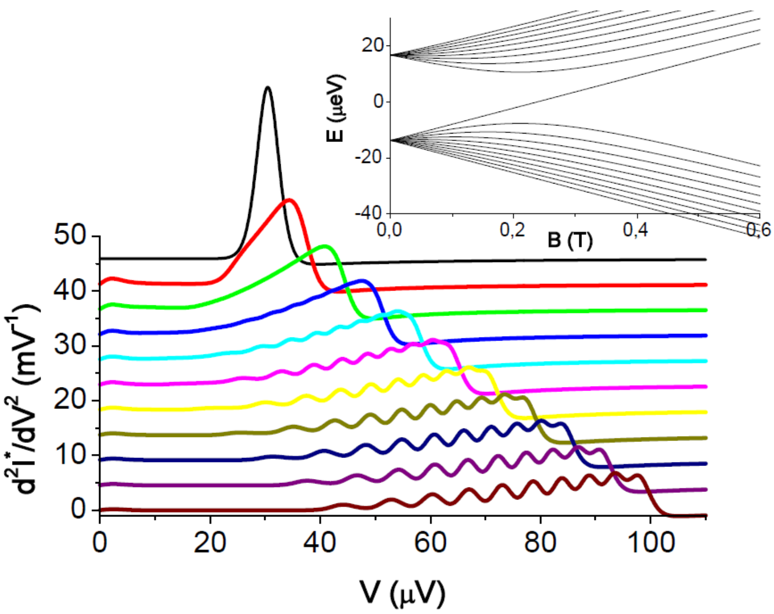

Energy spectrum of ^{209}Bi *in Silicon as a function of applied field and the corresponding* d^2I/dV^2 *spectra at* T = 10mK. *Spectra for different fields from 0 (black line) to 0.6T (brown line) are shown shifted vertically for clarity.*