Electromechanical Which–Path Interferometer

A. D. Armour
The Blackett Laboratory, Imperial College of Science, Technology and Medicine, London SW7 2BW, United Kingdom
M. P. Blencowe
Department of Physics and Astronomy, Dartmouth College, Hanover, New Hampshire 03755

We investigate the possibility of an electromechanical which–path interferometer, in which electrons travelling through an Aharonov–Bohm ring incorporating a quantum dot in one of the arms are dephased by an interaction with the fundamental flexural mode of a radio frequency cantilever. The cantilever is positioned so that its tip lies just above the dot and a bias is applied so that an electric field exists between the dot and the tip. This electric field is modified when an additional electron hops onto the dot, coupling the flexural mode of the cantilever and the microscopic electronic degrees of freedom. We analyze the transmission properties of this system and the dependence of interference fringe visibility on the cantilever–dot coupling and on the mechanical properties of the cantilever. The fringes are progressively destroyed as the interaction with the cantilever is turned up, in part due to dephasing arising from the entanglement of the electron and cantilever states and also due to the thermal smearing that results from fluctuations in the state of the cantilever. When the dwell time of the electron on the dot is comparable to or longer than the cantilever period, we find coherent features in the transmission amplitude. These features are washed out when the cantilever is decohered by its coupling to the environment.