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Phase Measurements in Aharonov-Bohm Interferometers

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Abstract: In this paper we address measurements of the resonant quantum transmission amplitude $t_{QD} = -i|t_{QD}|e^{i\alpha_{QD}}$ through a quantum dot (QD), as function of the plunger gate voltage V. Mesoscopic solid state Aharonov-Bohm interferometers (ABI) have been used to measure the ``intrinsic'' phase, $\alpha_{QD}$, when the QD is placed on one of the paths. In a ``closed'' interferometer, connected to two terminals, the electron current is conserved, and Onsager's relations require that the conductance G through the ABI is an even function of the magnetic flux $\Phi = \hbar c\phi/e$ threading the ABI ring. Therefore, if one fits G to $A+B \cos(\phi+\beta)$ then β only ``jumps'' between 0 and π, with no relation to α_{QD}. Additional terminals open the ABI, break the Onsager relations and yield a non-trivial variation of β with V. After reviewing these topics, we use theoretical models to derive three results on this problem: (i) For the one-dimensional leads, the relation $|t_{QD}|^2 \propto \sin^2(\alpha_{QD})$ allows a direct measurement of α_{QD}. (ii) In many cases, the measured G in the closed ABI can be used to extract both $|t_{QD}|$ and α_{QD}. (iii) For open ABI's, β depends on the details of the opening. We present quantitative criteria (which can be tested experimentally) for β to be equal to the desired α_{QD}: the ``lossy'' channels near the QD should have both a small transmission and a small reflection.

Key Words: interference in nanostructures, Aharonov-Bohm interferometer, quantum dots, resonant transmission

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