Extended Abstracts of the 1999 International Conference on Solid State Devices and Materials, Tokyo, 1999, pp. 254–255 **D-7-4**

Quantum Point Contact Position Dependence in Linear Quantum Dot Arrays

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1. Introduction

Quantum transport in a linear dot array, realized using multiple quantum point contacts (MQPC), strongly depends upon the position and size of the MQPCs, and the central dots which these define. Here, we study ballistic structures, with vanishing disorder, and which exhibit ballistic focussing peaks. Two types of geometry are studied: (1) the QPC openings are centered on the dots, which is referred to as "centrally connected," and (2) the QPC openings are at one side of the array, which is referred to as "edge connected." These are shown in the insets to Fig. 1. We previously have shown that a series of ballistic focusing (and back-scattering) peaks occur as the magnetic field is varied in the centrally-connected dot array [1]. In the present study, we show that these peaks do not appear in the edge-connected array, which clearly identifies their origin as a focusing effect connected with the lateral symmetry of the dot array.

2. Sample Properties

The MQPC structures are fabricated by standard split-gate techniques on a 2DEG of high mobility GaAs/GaAlAs heterostructure. This is patterned into standard Hall geometry structures with nominal voltage probe separation of 200 μm and width of 80 μm. The electron density and mobility are 3×10^{11} cm^{-2} and 50 m^2/Vs. The length and width of the MQPC defined dots is 0.6×1.0 μm, respectively. The QPC length is 0.1 μm in both array types.

3. Results and Discussion

In Fig. 1, we compare the magnetoresistance of the two array types. The centrally-connected array clearly shows additional peaks at specific values of the magnetic field. These peaks are missing in the edge connected array. These additional peaks are postulated to arise from focusing orbits which pass through one QPC, make an *odd* number of reflections off the walls and interfere at the entrance QPC. Such orbits are not possible in the edge-connected array, and their absence in the magnetoresistance supports this interpretation.

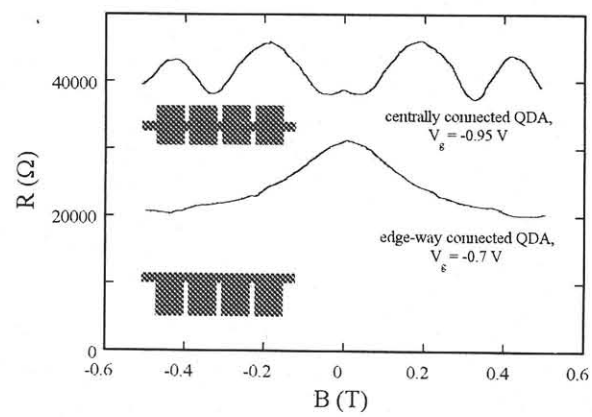

Fig. 1 Low field magnetoresistance of centrally connected QDA (upper) and of edge-way connected one (lower). The insets show the respective dot shape.

In Fig. 2, we have fit the ballistic focusing peaks with an assumed form and subtracted it from the overall magnetoresistance in order to exhibit the ballistic fluctuations connected with the density of states in the arrays. Unlike the focusing features, these ballistic fluctuations are also seen in the edge-connected arrays, clearly establishing their relationship to the intrinsic density of states of the dots themselves. We also note in Fig. 2 that the $B = 0$ peak disappears for a large range of the gate voltage, and evolves non-monotonically with this latter parameter. Hence, this peak cannot be associated with weak localization, but is a clear representation that *all* fluctuations are related to the density of states intrinsic to the dots, regardless of whether they are probed by magnetic field or by gate voltage sweep [2]. We note that these fluctuations appear differently than those in single dots, which is a result of the superlattice effects in these arrays [3]. We expect further studies on structurally-dependent transport will contribute new understanding to future mesoscopic device applications, such as quantum filters, resonators, qubits, and other devices.

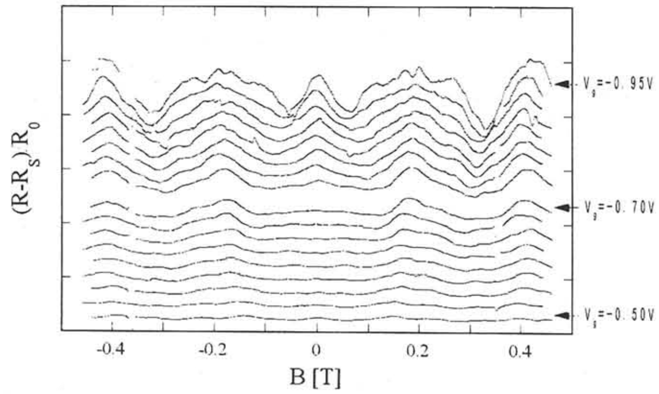

Fig. 2 Subtracted and normalized magnetoresistance of centrally connected QDA at various gate voltages.

Acknowledgements

Portions of this work were supported by grant in aid for Japan and the United States joint work based in JSPS and NFS. Also, this work were supported (Arizona State University) by the Office of Naval Research and the Defense Advanced Research Projects Agency.

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