Beating of Aharonov-Bohm Oscillations in a Closed-Loop Interferometer

Sanghyun Jo [a, b], Gyong Luck Khym [c], Dong-In Chang [a, b], Yunchul Chung [d], Hu-Jong Lee [a, b], Kicheon Kang [c], Diana Mahalu [e], and Vladimir Umansky [e]

[a] *Department of Physics, Pohang University of Science and Technology, Pohang, Korea*

[b] *National Center for Nanomaterials Technology, Pohang, Korea*

[c] *Department of Physics and Institute for Condensed Matter Theory, Chonnam National University, Gwangju, Korea*

[d] *Department of Physics, Pusan National University, Busan, Korea*

[e] *Department of Condensed Matter Physics, Weizmann Institute of Science, Rehovot, Israel*

One of the issues with closed-loop-type interferometers is beating in the Aharonov-Bohm (AB) oscillations. Recent observations suggest the possibility that the beating results from the Berry-phase pickup by the conducting electrons in materials with the strong spin-orbit interaction (SOI). In this study, we also observed the beats in the AB oscillations in a gate-defined closed-loop interferometer fabricated on a GaAs/AlGaAs two-dimensional electron-gas heterostructure. Besides the beat itself, the results showed noticeable characteristics that the h/2e period oscillation, imposed by Onsager relation, appeared only in the nodes of the beats and showed a parabolic distribution for varying voltages applied to one of the gates forming the interferometer. Since the GaAs/AlGaAs heterostructure has very small SOI the recently claimed Berry-phase-pickup mechanism of beats is ruled out. The often-cited multiple transverse sub-band effect is also ruled out because, unlike the case of mesa-defined interferometers, a single transverse sub-band is fine tuned in each arm of our gate-defined interferometer. We show all our observed results are well interpreted by the two-dimensional (2D) multiple-longitudinal-modes effect in a single transverse sub-band mode, without resorting to the SOI effect. In addition, the Fourier spectrum of measured conductance, despite showing the magnetic-field-dependent multiple h/e peaks that are very similar to those from strong-SOI materials, can also be interpreted by the 2D-effect.

Keywords : beat, Aharonov-Bohm oscillations, closed-loop interferometer, single transverse sub-band, parabolic distribution, spin-orbit interaction, two-dimensional multiple-longitudinal-modes effect