Nonlinear transport and inverted magneto-intersubband oscillations in a triple quantum wells

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Abstract

The inverted MIS oscillations in TQW systems is investigated. In our experiments, we have found that the current induced inversion of the magnetoresistance shows up in TQWs as a flip of the MIS oscillation pattern. We determined the critical magnetic field corresponding to the inversion of the quantum contribution to resistance for 3 different periods of MIS oscillations. Moreover, we compared the measurements for macroscopic size (250 μm) and mesoscopic size (5 μm) samples and found essential difference in the nonlinear transport behavior.

1. Introduction to Magneto Resistance Oscillations : SdH &MIS Oscillations

Magnetoresistance of two dimensional electron (2D) systems with more than one occupied subband e.g. DQW & TQWs in a perpendicular magnetic filed besides Shubnikov de Haas oscillations (SdH) shows magneto inter subband oscillations (MIS) due to possibility of inter-subband transitions [1-5].

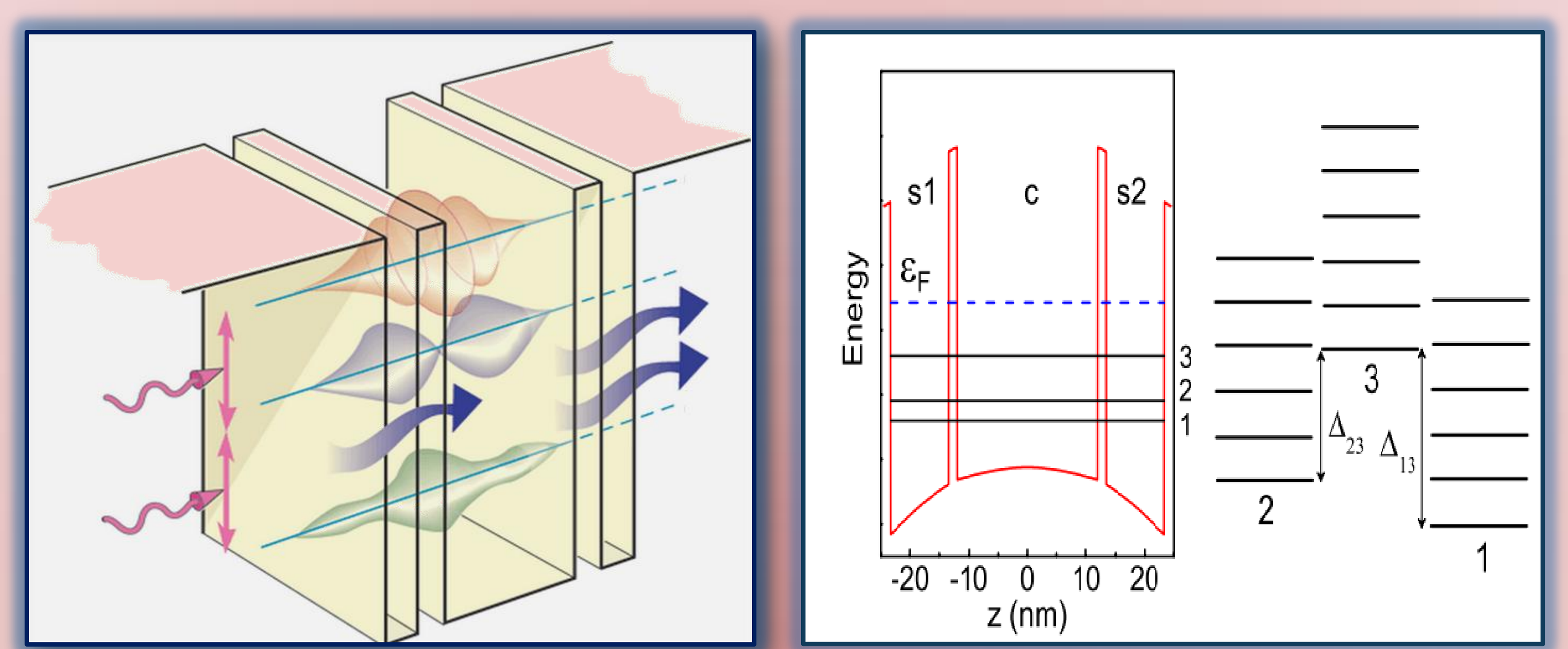

Fig.1. Tunneling & subband separation energies in multi quantum wells

MIS oscillations offer new possibilities in transport measurements, e.g. the determination of quantum lifetimes in regions where SdH oscillations are completely suppressed at high temperatures [2, 3].

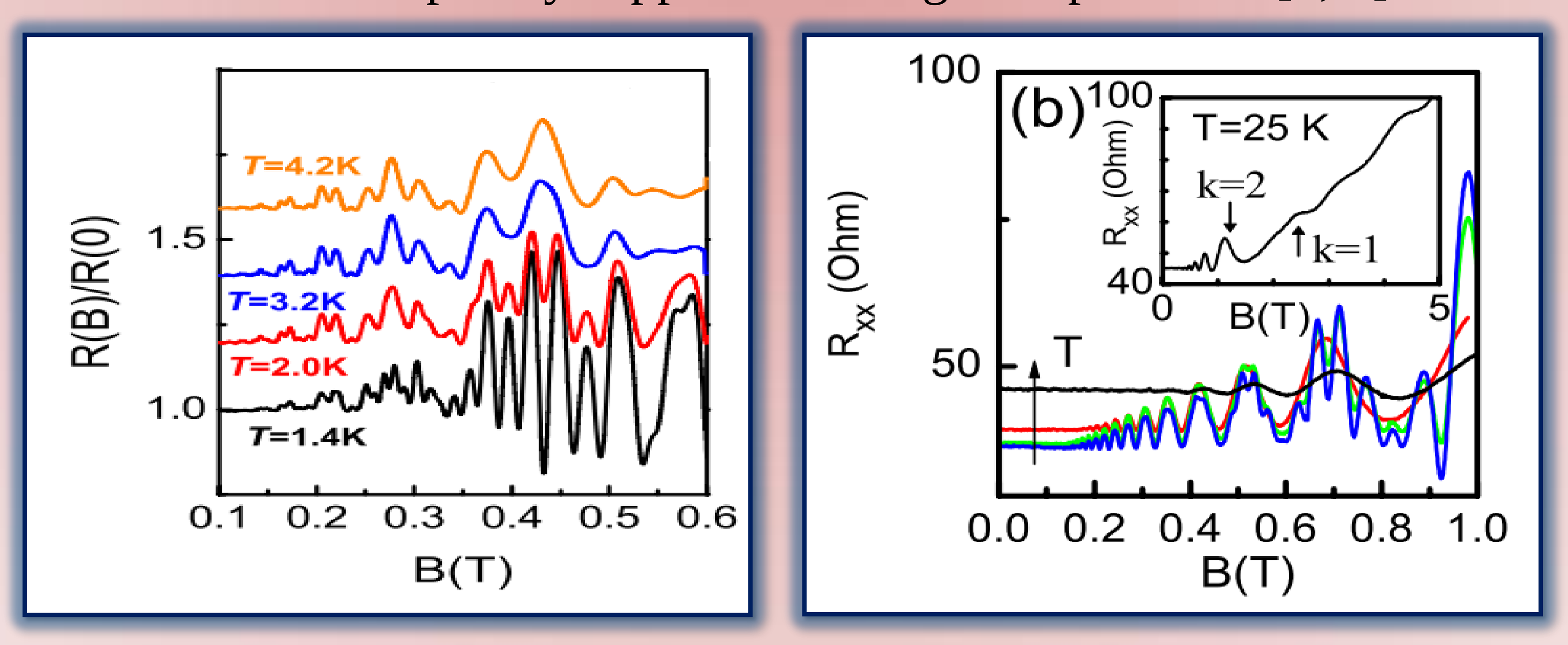

Fig.2. Temperature dependence of SdH Osc. & MIS Osc.

2.Motivations of this work

Observation of two important phenomena :

- ➢Oscillations of resistance as a function of either magnetic field or electric current
- ➢The current substantially reduces the resistance even at moderate applied voltages

3. Samples & Experimental Details

The characteristics of the samples of TQWs of GaAs are summarized in table 1. The hall bar structures are introduced on them using photolithography method. The resistance was measured by using the standard low frequency lock-in technique. The current dependence of magnetoresistance at different temperatures have been studied.

Left well A°	Barrier A°	Central well A°	Right well A°	Barrier A°	$n_s \times 10^{11}$ (Cm^{-2})	Hall bar dimensions (μm×μm)
100	20	220	20	100	10	250 ×100
100	14	450	14	100	7.06	5 ×100

Table 1. Characteristics of the samples and Hall bar structures

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4. Steps of Preparing Samples for Measurements

Fig.3. Steps of preparing samples for experiment

5. Results

Magnetoresistance of samples for both macroscopic and mesoscopic hall bars are presented in Fig.4.

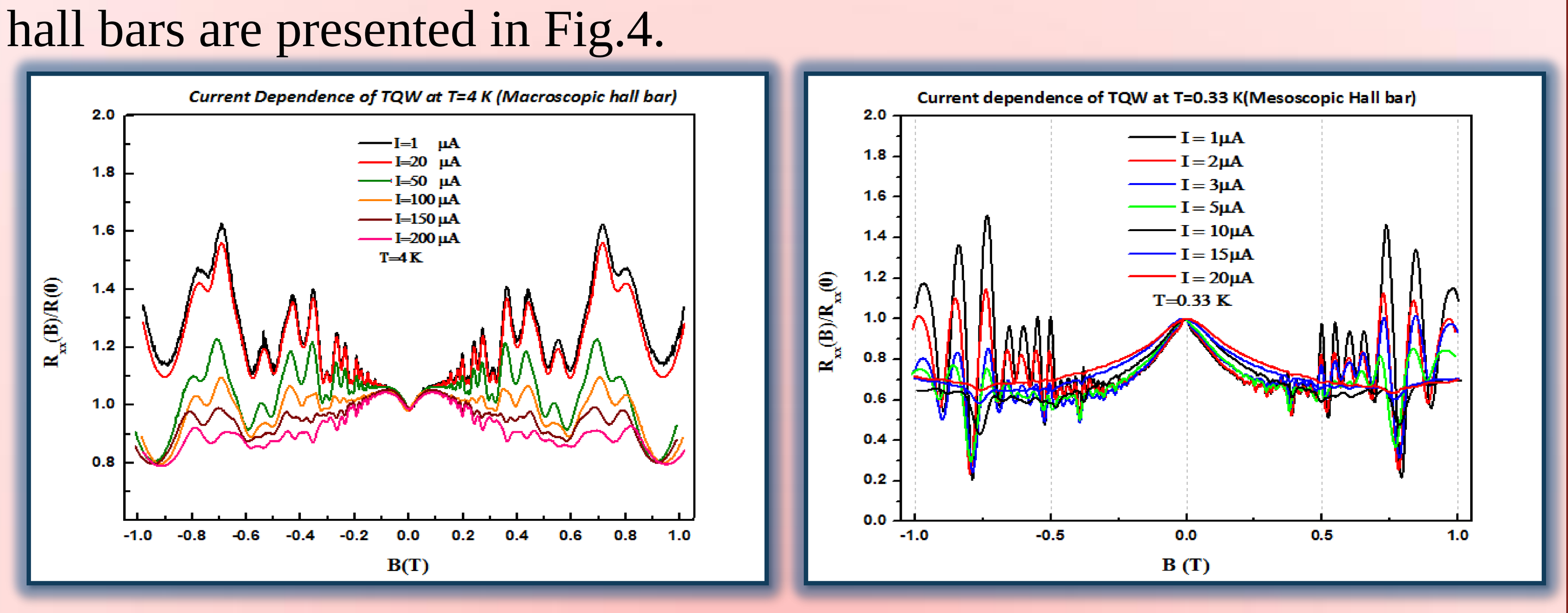

Fig.4. Magnetoresistance of samples at different current for temperatures

Using FFT analysis the density and sub-band separation energies are determined.

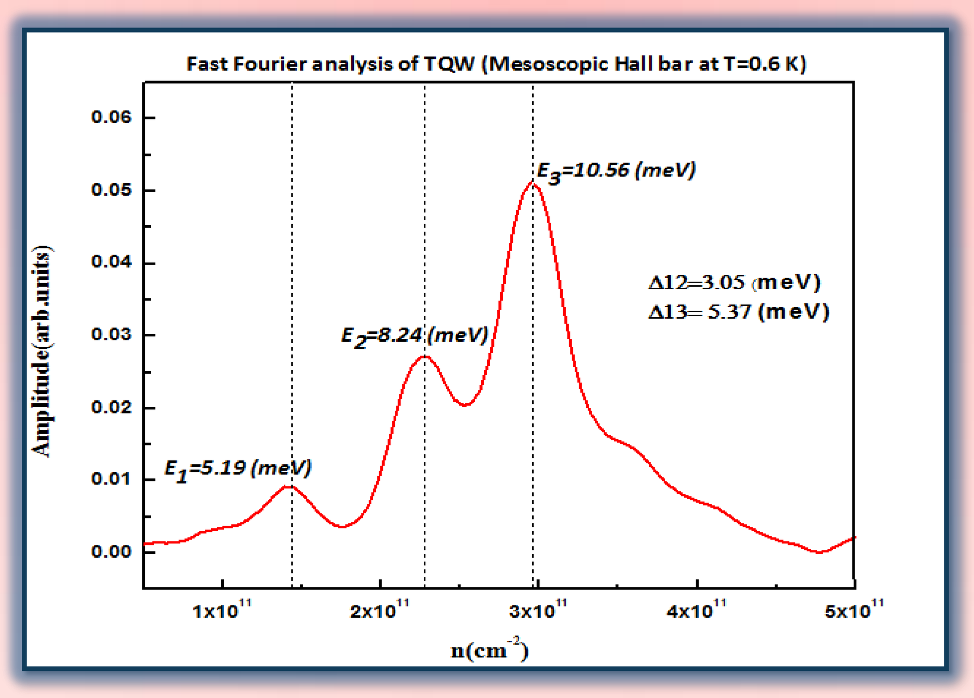

Fig.5. FFT analysis of magnetoresistance oscillations

6. Conclusion

The difference between magnetoresistance at zero magnetic field for the samples are related to different mechanisms of electron transport in samples. Nonlinear behavior of MIS oscillations are presented in both samples for different magnitude of current.

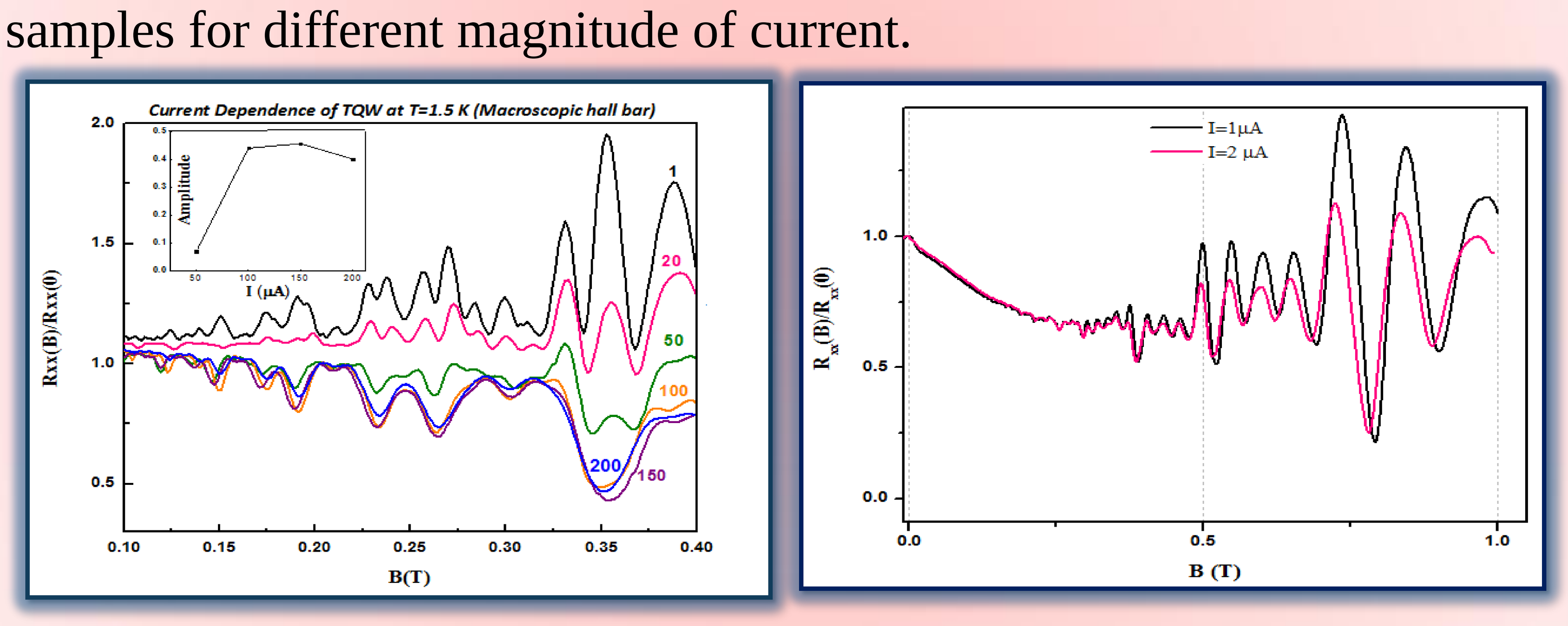

Fig.6. Inverted behavior of MIS Oscillations for macroscopic & mesoscopic hall bars

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