November 4, 2021

Ashot Melikyan,
Associate Editor,
Physical Review B.

Dear Professor Melikyan,

Thank you very much for your effort in managing the review process of our manuscript. We are also thankful for the reviewer comments, and believe the second version of the manuscript we submit herewith has been significantly improved by the constructive criticism we received. Additionally, the subsequent sections of this document discusses the reviewer comments and our responses to them.

Please note that in the following sections, the statements in **blue** are the comments of the reviewers. Our responses are shown in black letters and the modifications we have done to the manuscript are given in red.

General changes to the manuscript

- We have made minor changes in language and presentation to improve clarity, and to match the rest of the manuscript better to the changes done to address the reviewer's comments.
  - Section IV-A first paragraph -
    We prepare the thermal reservoirs B_L and B_R so that the temperature T_L of B_L is significantly higher than the temperature T_R of B_R TLS.

Response to the comments of Reviewer 1

We would like to thank the reviewer for bringing the deficiencies of our manuscript to our attention and providing constructive feedback to improve the quality of our work. We have considered all of your suggestions seriously and revised our paper manuscript as described below.

Comment 1 - My concern is that the manuscript is heavily skewed towards a purely mathematical formulation of the problem. It has a minimal connection to realistic two-dimensional electron systems. The manuscript does not discuss how the results can be applied to understanding mechanisms of charge transport in nanoelectronic devices and can be used to optimize device performance. Without such discussion, the manuscript will have a minimal impact on the community working on developing nanoelectronics.

We strongly agree with the reviewer that a reasoning on our theoritical results and their application in current nanoelectronic devices would be essential to the reader. Therefore, we have made a discussion on physical significance of our theoritical results and their possible employments in the optimization of nanoelectronic device performance. We have inserted a new Section VII to incorporate the above discussion into the manuscript. The total content of the section is given below,

Physical significance of outcomes

With the realization of 2DEGs in Si-MOSFETs (Metal Oxide Semiconductor Field Effect Transistors) [1], Klitzing *et al.* [2] made the first transport measurements on such systems to reveal the quantum Hall effect. The empirical discovery of these unusual properties marked the beginning of a whole new realm in condensed matter physics that continues to produce phenomenal advancements in electronic system. The quantum Hall effects in a 2DEG under a static magnetic field are discribed by plateaus quantized to integer values of the conductivity quantum $(e^2/\hbar)$ in the off-diagonal conductivity, with simultaneously peaks at inter-plateau transition for the diagonal conductivity [3]. This is due to the applied magnetic field and it changes the energy spectrum of 2DEG in a dramatic way. The magnetic field causes the density of states in 2DEG to split up into a sequence of delta functions, separated by an energy $\hbar\omega_0$, with ω_0 the cyclotron frequency which is depend on the appplied magnetic field. However, experimental results demonstrate that these Landau levels are broadened and the main source of these broadening in low temperatures is the disorders in materials [4, 5]. This behavour imply the oscillating behavior of the experimental measurement of longitudinal conductivity (the Shubnikov–de Haas oscillations) [3, 6].

Our theoritical analysis on longitudinal conductivity behaviour of dressed quantum Hall system developed by consideirng low temperature limit with gaussian impurity broadening assumptions. As illustrated in Fig. 4, we also able to demostrate same Shubnikov–de Haas conductivity oscillations as experimental results [3, 6] through our model. Under the undressed ($I = 0$) condition, our results are overlap with the conductivity measurement for quantum Hall systems. However, from our results given in Fig. 5, we demostrate that we are able to manipulate the broadening of these conductivity peaks using an external dressing field. In low temperature the principal cause of broadening of these conductivity peaks are impurity scattering and using an external dressing field we are able suppress the scattering which results in shrinkage both the scattering-induced broadening and the longitudinal conductivity.

Research on novel states of matter has driven the evolution of present-day nanoelectronic devices. In particular, controllable manipulation of material properties through a gate electric field has revolutionized the development material science and technology [7, 8]. Charge carrier concentration of a considering system is an imperative parameter that define the conductivity properties of system. We can manipulate that using the electrostatic field-effect machanism and it is an ideal tool to controll the conductivity in some specific systems. A 2DEG under static magnetic field with quantum Hall effects, is a excellent example that the gate electric field can be used to manipulate the conductivity. Considerable number researches has been performed using different type of 2D field-effect transistors(FETs) in magnetic fields to study the electronic transport in quantum limit [6, 9, 10, 11]. In the study done by Yang *et al.* [9], the authors have observed quantized Hall plateaus and Shubnikov–de Haas oscillations for longitudinal conductivity against gate volatage in black phosphorus FET under high magnetic fields in low temperatures. Since the Fermi level of the system can be altered with applied gate volatge, this behaviour can be easily map into our results given in Fig. 4. However, specility of our outcomes is we owned the capability of manipulate the broadening of the conductivity regions using an external dressing field. Although Yang *et al.* [9], achieved this broadening manipulation by changing the temperature in low range, in this study we present a general methematical describtion to perform that using only a high intensity electromagnetic field.

As a result of manipulating the broadening of conductivity regions, we can enhance the sensitivity of FETs which gives the ability of observe narrow changes in gate volage.

References

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Sincerely yours,

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