PRB - Response

Report of the First Referee

The authors of the manuscript developed a mathematical model of transport in quantum Hall systems. This work extends previous results for calculations of the transport properties of a two-dimensional electron gas illuminated by oscillating electromagnetic fields. The new results of the present manuscript provide interesting estimates of the dynamics of a 2DEG in the limit of highly intense radiation. These results deserve publication in an appropriate journal.

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. Moreover, this current research direction has a significant overlap with previous experimental and theoretical studies of quantum Hall systems that started with the observation of zero-resistance states in high mobility systems [Zudov et al, Phys. Rev. B 64, 201311 (2001), Mani et al, Phys. Rev. Lett. 92, 146801 (2004)] and gave rise to theoretical models for the phenomenon [Durst et al, Phys. Rev. Lett. 91, 086803 (2003), Dmitriev et al., Phys. Rev. B 71, 115316 (2005), Dmitriev et al, Phys. Rev. B 80, 165327 (2009)]. The present manuscript needs to connect to various known phenomena discussed earlier in the literature on quantum Hall systems. The manuscript will also provide more impact if it demonstrates how the new results can help to improve the future development of nanoelectronic devices. After these questions are addressed, the manuscript will be suitable for publication in Physical Review B. Otherwise, it will fit better to a more mathematically oriented journal.

I have a few specific questions.

1. The quantum Quantum Hall effect requires high mobility samples. In these samples, the structure of the disorder is usually complicated and combines both short-length potentials of impurities and long-length electrostatic inhomogeneities. The interplay of these components of disorder opens exciting questions about the transport properties of 2DEGs. What is the structure of disorder considered in the present manuscript and hidden in the notations for Vimp? What are the conditions for validity of eq. (15)?

2. If continuous illumination is applied to an electron system, the system will heat indefinitely. The distribution function is stabilized when the electron-electron and electron-phonon scattering mechanisms are included. What are the conditions of validity for eqs. (33-34)? The deviations of the distribution function from its equilibrium result in effects that can significantly overcome the equilibrium contributions, see Dmitriev et al, Phys. Rev. B 80, 165327 (2009). However, to capture these effects, a treatment within Floquet-Drude formalism is

insufficient and a complete quantum kinetic equation has to be analyzed. Can the authors argue why their results still present some interest to the community even if they potentially disregard more significant contributions?

3. The authors presented the results for the conductivity tensor's xx- and yy-components. They seem to be identical, apart of a dimensional factor (eB)^2 in the denominator. The equality of these two components is expected for isotropic systems. Does the polarization of the electromagnetic field break the isotropy? Do the two components of the conductivity remain equal even for an arbitrary direction of a linearly polarized field? Is there a non-Hall contribution to the xy-component?

Report of the Second Referee

This work presents theoretical results for the behavior of longitudinal conductivity in a non-interacting disordered quantum Hall system, irradiated with off-resonant electromagnetic radiation, using a recently developed calculation technique which allows treating the incoming radiation nonperturbatively. A remarkable result presented here is the radiation-induced narrowing of longitudinal conductivity lineshapes (Figs 4, 5).

The following questions need to be addressed before publication.

1. The paper is very low on comparison with experiments, for which there is a large amount of data available for the zero radiation case. I would like to see detailed analysis of how Figs 4 and 5 compare with available experimental data. Without this addition, physical relevance of such detailed calculations is questionable.

2. In the presence of disorder, Anderson localization and topologically protected edge modes are dominant considerations when calculating DC transport coefficients. How are these factors taken into account?

3. Can the authors reproduce the quantized Hall conductance of filled Landau levels in the presence of disorder? Please discuss.

4. The way some previous works are cited is disappointing. Example from page 8: “Despite this behavior being identified in previous works, their results did not coincide with the more accurate description of conductivity components in undressed quantum Hall systems.” This is not informative. Where, specifically, did results from earlier works fall short of reality, which have been better addressed in this work?

5. Adding some physical insight into the remarkable observation of radiation-induced narrowing of lineshapes (Figs 4, 5) will help elevate this work.

Points need to be address:

Referee 01

1 Result analysis

1. How the results can be applied to understanding mechanisms of charge transport in nanoelectronic devices and can be used to optimize device performance. How the new results can help to improve the future development of nanoelectronic devices.
2. Needs to connect to various known phenomena discussed earlier in the literature on quantum Hall systems.

4 Lit. Review

- Zudov et al, Phys. Rev. B 64, 201311 (2001)
- Mani et al, Phys. Rev. Lett. 92, 146801 (2004)
- Durst et al, Phys. Rev. Lett. 91, 086803 (2003)
- Dmitriev et al., Phys. Rev. B 71, 115316 (2005)
- Dmitriev et al, Phys. Rev. B 80, 165327 (2009)

2 Impurity Analysis

3. Q1: What is the structure of disorder considered in the present manuscript and hidden in the notations for Vimp? What are the conditions for validity of eq. (15). -> *Address short-length potentials of impurities and long-length electrostatic inhomogeneities*.
    - Dmitriev et al, Phys. Rev. B 80, 165327 (2009)

6 Heating

4. Q2: If continuous illumination is applied to an electron system, the system will heat indefinitely. The distribution function is stabilized when the electron-electron and electron-phonon scattering mechanisms are included. What are the conditions of validity for eqs. (33-34)? -> *Argue why their results still present some interest to the community even if they potentially disregard more significant contributions.*

3 Isotropy

5. Q3: The equality of these two components(xx and yy) is expected for isotropic systems. Does the polarization of the electromagnetic field break the isotropy?
6. Q3: Do the two components of the conductivity remain equal even for an arbitrary direction of a linearly polarized field? Is there a non-Hall contribution to the xy-component?

5 Hall Cond. Relation

7. Q3: Is there a non-Hall contribution to the xy- component?

Referee 02

7 Result analysis

1. Q1: The paper is very low on comparison with experiments, for which there is a large amount of data available for the zero radiation case -> *Detailed analysis of how Figs 4 and 5 compare with available experimental data.*
2. Q2: In the presence of disorder, Anderson localization and topologically protected edge modes are dominant considerations when calculating DC transport coefficient -> *Discuss the effect of these factors.*

5

Hall Cond. Relation

3. **Q3:** Can the authors reproduce the quantized Hall conductance of filled Landau levels in the presence of disorder? -> *Discuss this.*

7 Writing corrections

4. **Q4:** The way some previous works are cited is disappointing. Where, specifically, did results from earlier works fall short of reality, which have been better addressed in this work? -> *Reconsider the citations (ex : page8 - "Despite this behavior being identified in previous works").*

1 Result analysis

5. **Q5:** Add some physical insight into the remarkable observation of radiation-induced narrowing of lineshapes. -> *Detailed analysis of how Figs 4 and 5 observe with physical examples*