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Quantum Conductance within Luttinger Liquid from Parity Inversion and Time Rversal Symmetryic Interaction

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ABSTRACT The quantized conductance was produced due to dissipation within the Luttinger liquid from the parity inversion and time reversal symmetric interaction. For unitary time with Hermitian Luttinger liquid Hamiltonian and produced nonequilibrium conductivity and was renormalized due to interaction. We have studied the nonequilibrium dynamics and transport of parity inversion symmetric Luttinger liquid and the model was quenched from domain wall. The study was extended to initial ground state of a Hermitian interacting Luttinger liquid. We have used the model using the time evolving block decimation and have found the conductance inside the light core and depended on post-quench Hamiltonian and was quantized when the system was quenched to the non Hermitian Hamiltonian. The conductance was found when the system was quenched from an interacting initial state and showed that the initial state had no effect on conductance. The strength of the initial or final interactions in the case of Hermitian dynamics showed the quenched displayed a conductance that remained universal.

KEYWORDS Quantized, Conductance, Dissipation, Luttinger Liquid, Parity Inversion, Time Reversal, Symmetry, Nonequilibrium, Dynamics, Quenched, Block Decimation.

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INTRODUCTION

Bender et al. [1] and El-Ganainy et al. [2] studied that non Hermitian Hamiltonian model are invariant in response to the simultaneous action of the parity inversion and time reversal symmetry the conventional methods of statistical mechanics was applied. Miri et al. [3], Torres et al. [4] and Martinez et al. [5] presented that several exciting phenomena such as exceptional point, non Hermitian skin effect with majority of eigen states localized at the boundaries [6-7], topological transitions [8-9] and anomalous transport behavior. Ashida et al. [10] studied that a non Hermitian Hamiltonian produced naturally as the back action to continuous monitoring and controlled post selection measurement that suppressed the quantum jump processes. Lieb and Robonson [11] demonstrated that in Hermitian systems with short range interactions a maximal velocity for spreading the information was found. A quantum quench have been examined in Hermitian models. Pollmann et al. [12], Mestyan et al. [13] and Schoenauer et al. [14]

studied that nonequilibrium dynamics was homogeneous systems as in spin ½ chain or Hubbard chains. We have studied the behavior after the quantum quench in a homogeneous parity inversion time reversal symmetric Luttinger liquid. Giamarchi [15] showed that the conductance was found to be strongly renormalized by the interaction. Safi et al. [16] and Maslov et al. [17] showed that an ideal Luttinger liquid was connected to leads, the dc conductance depended on the properties of the leads of a quantum wire containing Luttinger liquid and was presented by the conductance quantum per spin orientation in the wire. Das et al. [18] investigated the quench dynamics and the universality of transport in a non Hermitian Luttinger liquid prepared in a domain wall state. Vidal [19] and Zwolak et al. [20] investigated numerically the non equilibrium numerically the non equilibrium dynamics in the non Hermitian lattice model using the time evolving block decimation algorithm and found perfect agreement with the bozonization results. Krinner et al. [21] and Yamamoto et al. [22] studied the electronic transport in neutral systems, e.g. cold atoms and found the results as in the case of homogeneous configuration and supersonic modes were visible in the density $n(x,t)$ or the current $j(x,t)$ profiles as well. Weld et al. [23], Choi et al. [24] and Nichols et al. [25] presented that domain walls state were realized experimentally in cold atoms setup by using magnetic field gradient.

METHOD

We have calculated the conductance across the interface favored the quenched in a one dimensional spinless lattice model. The initial state was constructed as a matrix product state by performing density matrix renormalization group calculations on the non interacting spin less Hamiltonian subject to a site dependent chemical potential realizing a domain wall. We have fixed the chain length while the nearest neighbor hopping represented the energy unit. The wave function was then evolved in time using the time evolving block decimation algorithm with a non Hermitian evolution operator was constructed from the Hamiltonian. We have computed the conductance numerically by using the relation

$$G = \frac{1}{2}\frac{d\, j(x,t)}{d\,\mu_0}\Bigg|_{\substack{x\to 0\\ \mu_0\to 0}}$$

Where $j(x,t)$ is the sum of current. The regular contribution to the current gives a contribution to the conductance $G_r = G_0$ with $G_0 = \frac{e^2}{h}$ the conductance quantum upon reinserting original units. The quantized conductance occurred by means of dissipation. The dissipation occurred within the Luttinger liquid due to imaginary interaction, while it have taken place within the leads in the conventional Hermitian setting. The non interacting spinless Hamiltonian was represented by

$$H_{inh}^{(lat)} = \sum_{m=1}^{N} \mu_m c_m^\dagger c_m + \sum_{m=1}^{N} \frac{j}{2}\left(c_{m+1}^\dagger c_m + \mathrm{Hc}\right)$$

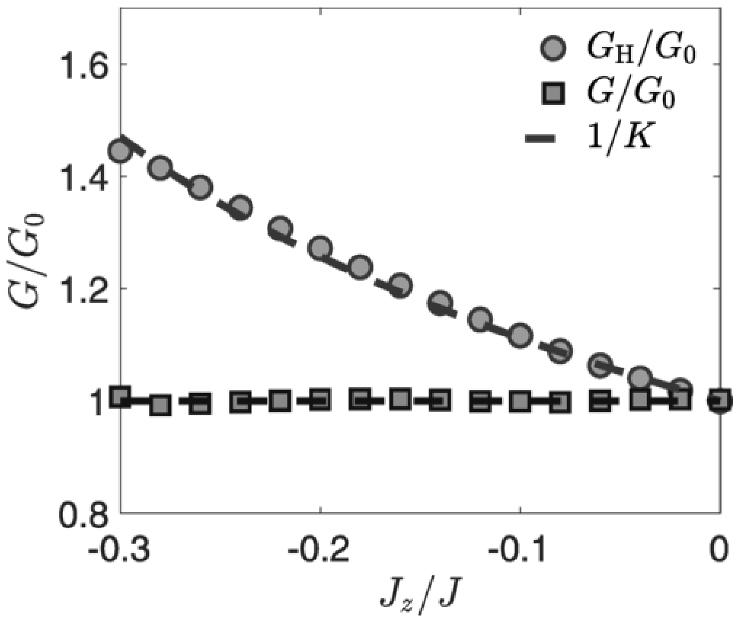
Where $\mu_m = \mu_0 \operatorname{sgn}\left(m - \frac{N}{2}\right), c_m^\dagger$ are the creation operators at site *m* along the chain, *N* =100 while *j* is the nearest neighbor hopping represented the energy unit. We have analysed the behavior after quench of quantum in a homogeneous parity inversion and time reversal symmetry Luttinger liquid. The conductance was found to strongly renormalized by the interaction. An ideal Luttinger liquid connected to leads the *dc* conductance depended on the properties of leads of quantum wire containing a Luttinger liquid and written by the conductance quantum $\frac{e^2}{h}$ per spin orientation. The universality of transport in a non Hermitian Luttinger liquid initially prepared in a domain of wall state. The supersonic modes were visible in the density $n(x,t)$ profiles were homogeneous configuration. Inside the regular light cone a long enough times for the system stabilized a non equilibrium steady state was developed with a current of c constant magnitude, irrespective of the strength of the interaction, the corresponding to a universal conductance

$$G = \frac{e^2}{L}$$

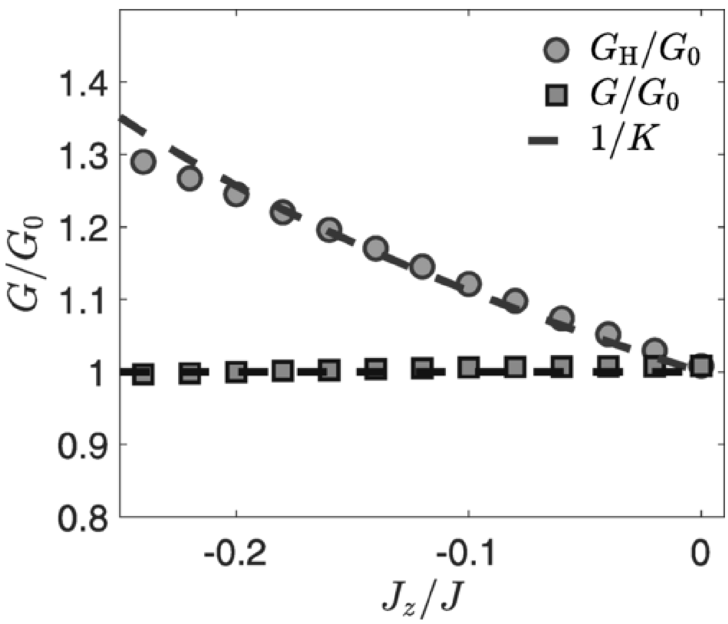
It was just like the case of non interacting spinless fermions. This was due to dissipation as in the case of Hermitian Luttinger liquid setup due to dissipation in the leads. The obtained results were compared with previous results.

RESULTS AND DISCUSSION

We have studied the quantum conductance within Luttinger liquid and transport of parity-inversion time reversal symmetry using non equilibrium dynamic. When the model was quenched from a quantum wall initial state. Due to non unitary time evolution the formation of supersonic modes on top of the regular light come both in the density and current profiles after quench was analysed. Graph (1) shows the plot of universal conductance of the parity inversion and time reversal for non Hermitian Luttinger liquid model. The value of coupling strength J_z the conductance remained universal and equal to the conductance quantum in perfect agreement with bosonization. Graph (2) shows the conductance of the parity inversion and time reversal non Hermitian Luttinger liquid. It also shows the display of the results for the Hermitian evolution by replacing $J_z \rightarrow -iJ_z$ and was found fit perfectly. We have found that the conductance inside the light cone depended on the post quench Hamiltonian and remained quantized when the system was quantized to the non Hermitian Hamiltonians. Graph (2) shows the results of the conductance when the system was quenched from an interacting initial state. Graph (2) also shows the initial state has no effect on the conductance. The analysis of behavior of quantum quench in a homogenous parity inversion and time reversal symmetry Luttinger liquid and found that the typical Luttinger liquid behavior was preserved in the long time limit but a short times the nonunitary evolution generated supersonic modes. The obtained results found were compared with previously obtained results of theoretical and experimental research works and were found in good agreement.



Graph 1: Plot of the universal conductance of non-Hermitian Luttinger model of the universal behaviour



Graph 2: Plot of conductance of parity-inversion non-Hermitian Luttinger model vs Hermitian interacting Luttinger liquid for quenched system.

CONCLUSION

The study of quantum conductance within Luttinger liquid from parity-inversion and time reversal symmetric interaction. We have presented the transport properties of purity inversion and time reversal symmetry Luttinger liquid after an interaction quench by using non equilibrium dynamics of transport. The parity inversion and time reversal symmetry Luttinger liquid the domain wall developed into a flat central region spreaded out ballistically faster than the conventional Lieb-Robinson maximal speed. We have found a universal conductance insensitive to the strength of the parity-inversion time reversal symmetric interaction. It was also found that the conductance was heavily renormalized by the Hermitian interaction. The quantized conductance was produced by dissipation within the Luttinger liquid from the parity inversion and time reversal symmetry interaction. The obtained results were found in good agreement with previously obtained results.

REFERENCES

[1] Bender. C. M. and Boettcher, 5, (1998), Phys. Rev. Lett. 80, 5243.

[2] El-Ganainy. R, Makris. K. G, Khajavikhan. M, Musslimani. Z. H, Rotter. S and Christodoulides, (2018), Nat. Phys.14, 11.

[3] Miri. M. A and Alu. A, (2019), Science 363, 42.

[4] Torres. L. E. F. F, (2020), J. Phys. Mater. 3, 014002.

[5] Martinez. Alvarez. V. M, Barrios. Vargas. J. E and Foa Torres. L. E. F, (2018), Phys. Rev. B 97, 121401(R).

[6] Yao. S and Wang. Z, (2018), Phys. Rev. Lett. 121, 086803.

[7] Longhi. S, (2019), Phys. Rev. Research 1, 023013.

[8] Zeuner. J. M, Rechtsman. M. C, Plotnik. Y, Lumer. Y, Nolte. S, Rudner. M. S, Saegev. M and Szameit. A, (2015), Phys. Rev. Lett. 115, 040402.

[9] Lee. T. E, (2016), Phys. Rev. Lett. 116, 133903.

[10] Ashida. Y, Furukawa. S and Veda. M, (2016), Phys. Rev. A. 94, 053615.

[11] Lieb. E. H and Robinson. D. W, (1972), Commun. Math Phys. 28, 251.

[12] Pollmann. F, Haque. M and Dora. B, (2013), Phys. Rev. B. 87, 041109 (R).

[13] Mestyan. M, Pozsgay. B, Takacs. G and Werner. M. A, (2015), J. Stat. Mech.: Theory Exp. P04001.

[14] Schoenauer. B and Schuricht. D, (2019), Phys. Rev. B. 100, 115418.

[15] Giamarchi. T, (2004), Quantum Physics in one Dimension, (Oxford University Press, Oxford).

[16] Safi. I and Schulz. H. J. (1995), Phys. Rev. B. 52, R17040.

[17] Maslov. D. L. and Stone. M, (1995), Phys. Rev. B. 52, R5539.

[18] Das. J. P, Chowdhury. C and Setlur. G. S, (2019), Theor. Math. Phys. 199, 736.

[19] Vidal. G, (2003), Phys. Rev. Lett. 91, 147902.

[20] Zwolak. M and Vidal. G, (2004), Phys. Rev. Lett. 93, 207205.

[21] Krinner. S, Stadler. D, Husmann. D, Brantut. J. P. and Esslinger. T, (2015), Nature (London), 517, 64.

[22] Yamamoto. K, Ashida. Y and Kawakami. N, (2020), Phys. Rev. Research. 2, 043343.

[23] Weld. D. M., Medley. P, Miyake. H, Hucul. D, Pritchard. D. E. and Ketterle. W, (2009), Phys. Rev. Lett. 103, 245301.

[24] Choi. J. Y, Hild. S, Zeiher. J, Schaub. P, Rabio-Abadal. A, Yefsah. T, Khemani. V, Huse. D. A, Bloch. J. and Goss. C, (2016), Science 352, 1547.

[25] Nichols. M. A, Chenk. L. W, Okan. M, Hartke. T. R, Mendez. E, Senthil. T, Khatami. E, Zhang. H and Zwierlein, (2019), Science 363, 383.