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Peer Review

Review of: "Dynamical Edge Modes in Yang-Mills Theory"

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The manuscript titled "Dynamical Edge Modes in Yang-Mills Theory" presents a detailed analysis of the dynamics of Yang-Mills theory on a Cauchy slice with a boundary, focusing on the decomposition of phase space into bulk and edge degrees of freedom. The work extends previous results in abelian gauge theory and provides important insights into the role of edge modes in non-abelian gauge theory. The presentation is clear, and the authors demonstrate a solid understanding of the underlying physics. The results are well-supported by rigorous analysis, and the paper makes an important contribution to the field.

However, there are several issues that need to be addressed to strengthen the manuscript. These issues concern both conceptual clarifications and technical details, which I outline below.

1. Clarification on Bulk and Edge Mode Decoupling:

The authors provide a compelling analysis of the symplectic structure, showing that the phase space factorizes into independent bulk and edge parts. The bulk and edge fields Poisson-commute, implying a decoupling of the degrees of freedom in phase space. However, the authors observe that the Hamiltonian evolution couples the bulk and edge modes. This coupling is crucial to the dynamics and deserves more discussion. While the paper demonstrates that the decoupling occurs in a weak-field expansion at quadratic order, the general behavior of the coupled dynamics, particularly for the full Hamiltonian, remains less clear. I recommend that the authors provide a more thorough discussion of the implications of this coupling, especially in the context of a boundary in Yang-Mills theory.

2. Temporal Evolution and Gauge Conditions:

There is a critical issue regarding the preservation of gauge conditions under temporal evolution. In Section 3, the authors introduce gauge conditions (3.3) and (3.6) in order to achieve the bulk-edge splitting of the symplectic structure. However, it is unclear whether these conditions are preserved by

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the temporal evolution. Specifically, the consistency of these gauge conditions, particularly the Coulomb gauge, under the Hamiltonian evolution should be clarified. The authors should address whether these conditions are maintained during the dynamical evolution, as this is essential for ensuring that the decomposed phase space remains well-defined at all times. Without such clarification, the discussion of the splitting could be misleading.

In conclusion, while the manuscript presents a significant advance in understanding the dynamics of Yang-Mills theory with a boundary, several issues need to be addressed to ensure the clarity and consistency of the results. I recommend publication, subject to the authors addressing the above points in a revised version of the manuscript.

Declarations

Potential competing interests: No potential competing interests to declare.