Recently, notions of quantum information, such as entanglement entropy and circuit (or computational) complexity, are attentively studied in relation to quantum field theories. This article deals with the computation of geometric complexity for link complement states in Chern-Simons theory. Let M be a closed 3-manifold where the Chern-Simons theory is defined. The link complement states can be considered when the boundary of M is given by a disjoint union of n tori ($n \in \mathbb{Z}$). These link complement states have been studied in the investigation of entanglement entropy in Chern-Simons theory [1, 2]. By use of these results the authors present a new definition of geometric complexity for link complement states in Abelian, as well as non-Abelian, Chern-Simons theory.

In the case of $U(1)_k$ Chern-Simons theory, the complexity is shown to be given in terms of Gauss linking numbers modulo the level k. In the $SU(2)_k$ Chern-Simons theory the authors consider the complexity for torus link complement states in particular and show that it can be computed from the complexity of a single knot state and information of colored Jones polynomials for the torus link. It is also argued that the maximal complexity is given by $\mathcal{C}_{max} \propto N$ for the Abelian case, N being the number of degrees of freedom in the system, while $\mathcal{C}_{max} \propto \sqrt{N}$ for the non-Abelian case.

The complexity of knot states in Chern-Simons theory is also studied and defined in connection to modular transformations of the torus [3]. The article under review presents a different (and more physical) definition of the complexity. The article also illustrates quantitative computations of the non-Abelian complexity for a simple case.

References

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