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Axion QED as a Lattice Gauge Theory and Non-Invertible Symmetry

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We formulated axion QED on a lattice using a modified Villain formalism. While the axion-photon coupling in the continuum theory is straightforward, we found that the corresponding coupling in the lattice gauge theory using the modified Villain formalism is more complex. As a result, we discovered that the gaugeinvariant 't Hooft loop requires a surface inside it. Additionally, we discussed the non-invertible symmetry related to the axion's 0-form shift symmetry, namely the axial transformation. In the continuum theory, it has been reported that a membrane is stretched inside the 't Hooft loop under the action of the non-invertible symmetry operator. However, starting from our formulation, we demonstrated that no nontrivial change occurs to the 't Hooft loop under such an action.

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