Complex Langevin analysis of 2D U(1) gauge theory on a torus with a θ term

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Monte Carlo simulation of gauge theories with a theta term is known to be extremely difficult due to the sign problem. We consider the complex Langevin method (CLM), which is one of the approaches to overcome this problem. As a first step, we apply the method to 2D U(1) gauge theory with a theta term, which can be solved analytically. We find that naive implementation of the method fails because of the topological nature of the theta term. In order to circumvent this problem, we introduce a puncture on the torus. We find that the CLM works and reproduces the exact results for the punctured model even at large theta. We also prove that the punctured model is equivalent to the infinite volume limit of the original model inside the fundamental domain of theta.

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