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Complex Langevin analysis of four-dimensional SU(2) gauge theory with a theta term

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The Monte Carlo simulation of the gauge theory with a theta term is difficult due to the sign problem. We use the complex Langevin method to overcome the problem. In our previous work on two-dimensional U(1) gauge theory with a theta term, we were able to reproduce the exact solution by introducing a puncture on the torus. We also proved that the effect of the puncture disappears in the infinite volume limit as long as $|\theta|<\pi$. In this study, we extend this method to four-dimensional SU(2) gauge theory. Recently the analytic study of 't Hooft anomaly matching condition predicted two possible phase structures around $\theta=\pi$ for this theory. We discuss the possibility of investigating the phase structure by the complex Langevin simulation.

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