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Grassmann Tensor Renormalization Group for two-flavor massive Schwinger model with a theta term

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We use the Grassmann tensor renormalization group method to calculate the free energy of the $N_f = 2$ Schwinger model with a 2π periodic θ term in a broad range of mass. We confirm the numerical results agree with the analytical ones in the large mass limit, and check the qualitative consistency in the small mass limit. We also calculate the vacuum degeneracy, which is consistent in the large mass regime. The θ dependence is then examined in the finite mass region, which is inaccessible in analytical calculations. Our numerical study suggests that the finite mass effects lead to a different result than analytic values in both large and small mass regimes.

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