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Investigating the Phase Structure of Large N Unitary Matrix Models using Complex Langevin Method

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Using complex Langevin method we examine the phase structure of complex unitary matrix models and compare the numerical results with analytic results found at large number of colors. The actions we consider are manifestly complex, and thus the dominant contributions to the path integral comes from the space of complexified gauge field configurations. For this reason, the eigenvalues of unitary matrices lie off the unit circle and explore out in the complex plane. One example of a complex unitary matrix model, with Polyakov line as the unitary matrix, is an effective description of a QCD at finite density and temperature, with finite number of colors and quark flavors, defined on a compact manifold. A distinct feature of this model, the occurrence of a series of Gross-Witten-Wadia transitions, as a function of the quark chemical potential, is reproduced using complex Langevin dynamics. We simulate several other observables including Polyakov lines and quark number density, for large number of colors and quark flavors, and found excellent match with the analytic results.

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