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Gaussian state approximation for real-time dynamics of gauge theories: Lyapunov exponents and entanglement entropy

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We describe a numerical method which allows to go beyond the classical approximation for the real-time dynamics of many-body systems by approximating the many-body Wigner function by the most general Gaussian function with time-dependent mean and dispersion. On a simple example of a classically chaotic system with two degrees of freedom we demonstrate that the Gaussian state approximation is accurate for significantly smaller field strengths and longer times than the classical one. We use this method to study quantum Lyapunov exponents and the generation of entanglement entropy in dimensionally reduced Yang-Mills theory and in 10d supersymmetric Yang-Mills theory (BFSS matrix model). We find that quantum corrections tend to decrease the Lyapunov exponents, and make them vanish in the low-temperature confining phase. This behavior ensures the validity of the Maldacena-Shenker-Stanford bound on Lyapunov exponents. Entanglement entropy production rate is found to be larger than the Lyapunov exponents, and consistent with quantum information scrambling. We further discuss the applicability of the Gaussian state approximation to real-time simulations of higher-dimensional Yang-Mills theory.

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