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INVITED TALK: A Unified Theory of Barren Plateaus for Deep Parametrized Quantum Circuits

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Abstract: Variational quantum computing schemes have received considerable attention due to their high versatility and potential to make practical use of near-term quantum devices. Despite their promise, the trainability of these algorithms can be hindered by barren plateaus (BPs) induced by the expressiveness of the parametrized quantum circuit, the entanglement of the input data, the locality of the observable or the presence of hardware noise. Up to this point, these sources of BPs have been regarded as independent and have been studied only for specific circuit architectures. In this work, we present a general Lie algebraic theory that provides an exact expression for the variance of the loss function of sufficiently deep parametrized quantum circuits, even in the presence of certain noise models. Our results unify under one single framework all aforementioned sources of BPs by leveraging generalized (and subsystem independent) notions of entanglement and operator locality. Finally, our results lead to a critical question: Does the inherent structure that precludes the presence of BPs in a variational model (a requisite for trainability) simultaneously render it classically simulable?

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