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Circuit complexity through phase transitions and its consequences in quantum state preparation

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How much does it cost to generate a target quantum state from another reference state?
This is a rather general question that has been discussed in quantum information for obvious reasons. In quantum computation it is desirable to obtain the result with the minimum set of gates. This number is, roughly speaking, the cost and it is called
Complexity. In this talk, I will introduce different ways to compute the complexity to prepare the ground states, i.e. the target state is the ground state of a given Hamiltonian. We will be interested in the situation where on the way from the reference to the target we cross a critical point. We will work different examples and draw general consequences. We will calculate exactly the complexity for integrable models, like the anisotropic XY, quasi-soluble like the Dicke model. As well as numerical results for non-integrable Hamiltonians (ZZXZ model). We will discuss general properties through scaling hypotheses and find optimal ways to reach the target state. All this theory will be applied to real algorithms: we will calculate the circuit complexity for varational quantum eigensolvers (VQE) and adiabatic algorithms (with and without shortcuts). As a take home message, we will show universal scaling relationships for circuit complexity. For systems of finite size and depending on the critical exponents, this quantity can be subextensive, extensive or superextensive. In the thermodynamic limit, we will discuss how complexity diverges.

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