ON THE POWER OF GEOMETRICALLY-LOCAL CLASSICAL AND QUANTUM CIRCUITS

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Abstract

We show a relation, based on parallel repetition of the Magic Square game, that can be solved, with probability exponentially close to 1 (worst-case input), by 1D (uniform) depth 2, geometrically-local, noisy (noise below a threshold), fan-in 4, quantum circuits. We show that the same relation cannot be solved, with an exponentially small success probability (averaged over inputs drawn uniformly), by 1D (non-uniform) geometrically-local, sub-linear depth, sub-quadratic size, classical circuits consisting of fan-in 2 NAND gates. Quantum and classical circuits are allowed to use input-independent (geometrically-non-local) resource states, that is entanglement and randomness respectively. To the best of our knowledge, previous best (analogous) depth separation for a task between quantum and classical circuits was constant v/s sub-logarithmic, although for general (geometrically non-local) circuits. Our hardness result for classical circuits is based on a direct product theorem about classical communication protocols from Jain and Kundu [JK22]. As an application, we propose a protocol that can potentially demonstrate verifiable quantum advantage in the NISQ era. We also provide generalizations of our result for higher dimensional circuits as well as a wider class of Bell games.

Venue

PAMU Seminar Hall

A.N. Kolmogorov Building, ISI, Kolkata

Date & Time

23 February, 2024
03:00 PM

Everyone is invited to attend