Boson sampling simulation enhanced by FPGA based data-flow engines

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As was shown by the pioneering work of Scott Aronson and Alex Arkhipov, bosonic systems are promising candidates to demonstrate quantum advantage. Due to the nature of quantum states describing indistinguishable bosons, the exact simulation of particle number resolved bosonic systems is computationally very hard. One of the main objectives of the Laboratory of Quantum Computer Simulators in Budapest (launched in the collaboration of the Department of Physics of Complex Systems, the Department of Programming Languages and Compilers of the Eötvös Loránd University and the Department for Computational Sciences of Wigner Research Centre for Physics) is to develop new methods to make the simulation of these systems more efficient.

According to our recent experiences FPGA based data-flow engines (DFE’s) seem to be promising architectures to enhance the simulation of bosonic systems on classical hardware. On platforms supporting data-flow programming model one has an instant access to data generated during the computational process without the overhead of passing the data between the memory and central processing units (CPU’s).

In particular, we argue that DFE’s are suitable to evaluate matrix functions associated with the simulation of different variants of Boson Sampling with high precision. Such a special matrix function is the permanent of a squared matrix. In the talk I will present our DFE implementation to calculate the permanent of a unitary matrix describing a bosonic quantum interferometer using 128 bit fixed point arithmetics. We provide a benchmark of our implementation to calculate the permanent of a matrix up to a size of 28x28 on a single FPGA chip, and up to a matrix size of 40x40 on a dual FPGA chip configuration. Our results outperforms previous benchmarks of permanent calculation both in performance and in numerical precision. We incorporated our DFE permanent calculator into the Piquasso bosonic quantum computer simulator.

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