Two-qudit (d=4) ion quantum processor on a quadrupole optical transition in $^{171}Yb^{+}$

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Trapped ion quantum processors now demonstrate remarkable results, including large coherence time, high fidelities of initialization, readout, single- and two-qubit gates as well as full connectivity. However, there is still a great challenge in raising number of ion qubits above 20-30 qubits. One of the promising approaches to quantum processors scaling is switching from quBits to quDits – increasing quantum information encoding density in each particle. In the talk current results on the development of a two-qudit (d = 4) quantum processor based on a quadrupole optical transition at 435 nm in $^{171}Yb^{+}$ are presented. Ground state cooling of axial modes on this transition as well as individual particle addressing and readout were implemented. Universal gate set was experimentally demonstrated and their fidelities were measured. Rather moderate fidelities at the moment are limited by insufficient ions cooling and addressing laser phase noise. Future plans on the system scaling and fidelity improvements via improved trap design and laser noise filtering will be presented.