Optical control hardware for ion quantum processors

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In the project IQuAn, an ion-based quantum processing unit is being developed with connectivity to high performance computing. For the operation of the processor, laser light must be conditioned with controllable frequency, intensity, and switching capabilities to cool and perform operations on the ions. For this purpose, TOPTICA will design and produce modular, fully-fiber-coupled control units that

process the laser light and prepare it for the experiments, replacing standard table-top solutions in a rack-mounted, compact and scalable form. In addition, TOPTICA will investigate methods for improved laser frequency control and stabilization, as well as PIC-based solutions, in collaboration with other partners.



TOPTICA's role in IQuAn

Light Processing Unit (LPU) modular platform

Develop compact and robust light processing and control techniques for the quantum processor

Rack based solutions

- Compact and hands-off
- Fully fiber coupled
- Modular construction
- Passive stability
- · Cable management





Modules

I. Interface Cube

- Polarization cleaning
- Beam splitting, folding
- Power monitoring

II. Double pass AOM

- Frequency shifts
- Intensity modulation
- Switching

III. Switch EOM

IV. Sideband EOM

V. Automated Fiber Coupling









LPU Prototype



First prototype testing

LPU Interfaces

- Each T-RACK and LPU comes with its own electronics
- Power monitoring with photodiodes via GUI
- Automatic beam alignment for outputs can be triggered via GUI
- Interfaces AOMs & EOMs: control and drivers are taken over by user



Frequency control of lasers for quantum processors

- Methods for drift-free and long-term stable laser stabilization to frequency references
- Rack-mounted system with phase-locked coupling of lasers for quantum gates currently under characterization

- Functionality
- Effficiency of modules
- Passive stability (Thermal, mechanical)
- Improvement of functionalities & efficiencies



Beam splitting and combining with PICs

 Investigating suitability of photonic integrated circuit methods to perform relevant functionalities within the developed platform

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