FermiQP Integrated high-power and low-noise laser systems

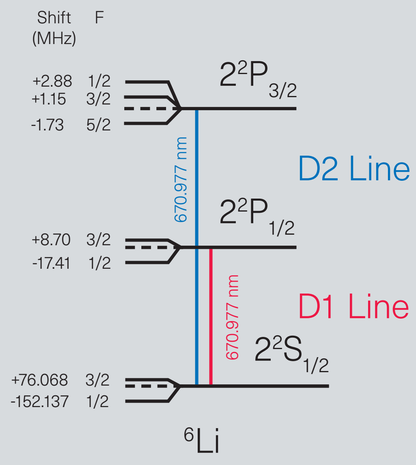
Steffen Schmidt-Eberle, Marcel Holtz, Matthias Scholz, Georg Heinze, Armin Zach, Stephan Ritter, Jürgen Stuhler

FermiQP is one of nine funded projects by the Federal Ministry of Education and Research for the investigation of new and scalable quantum processors within the program „Quantenprozessoren und Technologien für Quantencomputer“. FermiQP has the goal to develop a quantum computer demonstrator based on neutral Lithium-6 atoms in an optical lattice. Two major characteristics of the new architecture are its scalability due to parallelized operations and long coherence times. This goal imposes high demands to the achievable power and the phase and intensity stability of the laser systems which drive the quantum computer. TOPTICA investigates underlying laser technologies and develops these laser systems which feature unprecedented specifications.

Lithium-6 for Quantum Computing

Overview

Laser cooling at 671 nm



from Rev. Sci. Instrum. 91, 011101 (2020)

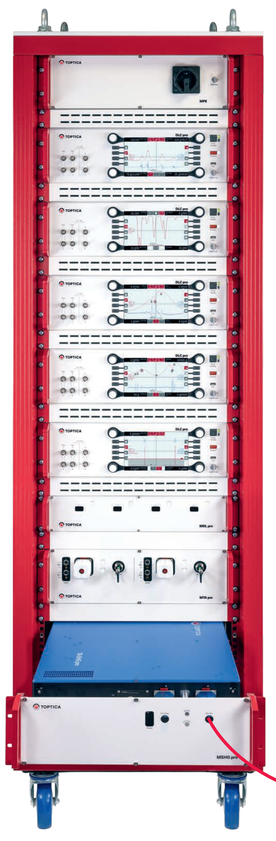
Raman laser pair at 323 nm for single-qubit operations

Requirements

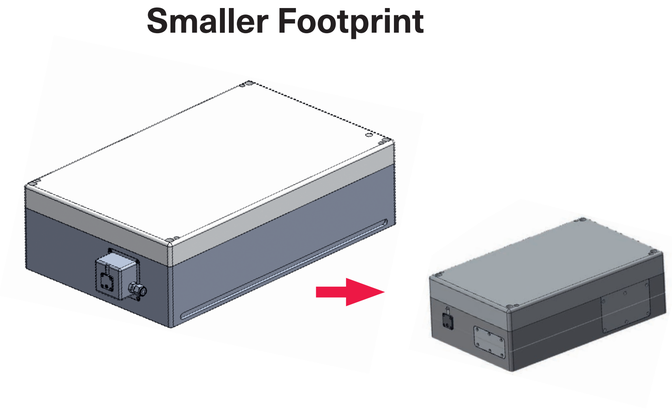
- High power for MOT, repump, imaging, Raman cooling, etc.
- Three frequency ranges
- High power for parallel operations → scalability
- Low phase and intensity noise for high-fidelity gates

Miniaturized SHG systems

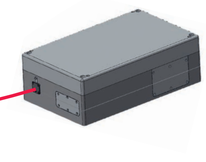
- More compact design → Higher stability (power, pointing)
- Lower weight → Short warmup time
- Smaller optics & mechanics → Lower material costs



Smaller Footprint



UV extension for T-RACK



High-power frequency converted laser systems

Present solution:
TA-FHG pro

FermiQP

External Cavity Diode Laser → **Optical Amplifier** → **Second Harmonic Generation** → **Second Harmonic Generation**

New concepts for optical amplification

Miniaturized SHG

Optical amplifiers

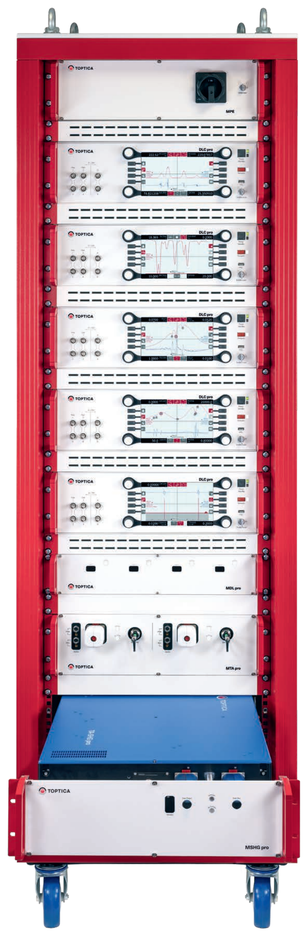
Amplifier types

- Solid state amplifiers
- Semiconductor amplifiers
- Fiber based amplifiers

Requirements

- High power
- Low intensity noise

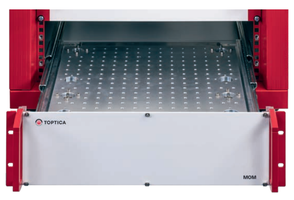
Full integration with TOPTICA´s Rack based tool box



MSHG pro

MTA pro

MOM



Advantages of Rack based solution

- Compactness
- Modularity
- Uncompromised stability
- Professional cable and fiber management

Supported by

Bundesministerium für Bildung und Forschung

quanten technologien