Evolving Laser System Solutions for Quantum Computing

Stefan Spälter, Director Product Management Quantum Technologies, TOPTICA Photonics AG

EPIC Technology Meeting: Photonics for Quantum Computers

All Wavelengths.
190 nm - 0.1 THz

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TOPTICA Group: Key Figures

TOPTICA Headquarter Gräfelfing/Munich

Technology

Diode Laser Systems	190 – 4000 nm
Ultrafast ps/fs Fiber Lasers	390 – 15000 nm
Optical Frequency Combs	420 – 2000 nm
CW Fiber Lasers & Amplifiers	488 – 1570 nm
Terahertz Generation	0.1 – 6 THz
High Power Laser Diodes	630 – 1120 nm (TOPTICA eagleyard)

Key Figures

Employees	560
Revenues	127 Mio €
Founded	1998

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TOPTICA Photonics: International

TOPTICA Photonics Distributors

Lastek
Australia

Simco Global Technology
India

Lahat Technologies
Israel

Jinsung Laser
Korea

EuroLase Ltd.
Russia

Precision Technologies
Singapore

Luxton Inc.
Taiwan

TOPTICA Photonics UK
UK

TOPTICA Photonics offices
Germany, USA, Japan, China, France

TOPTICA Projects
Germany

TOPTICA eagleyard
Germany

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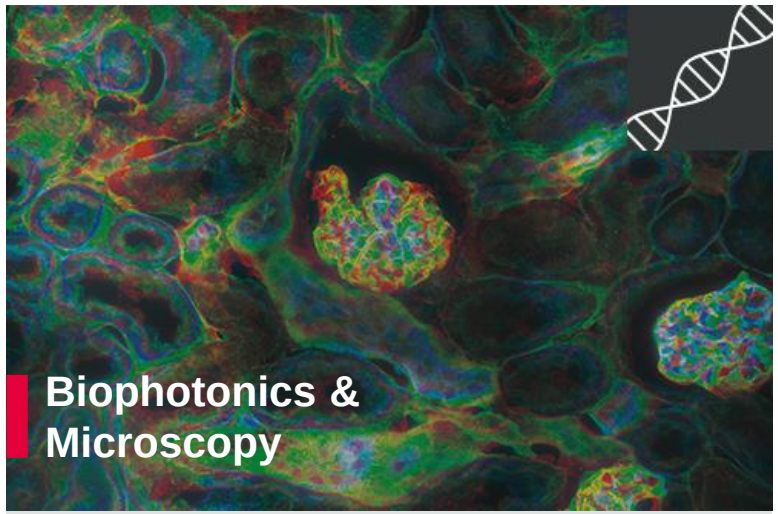
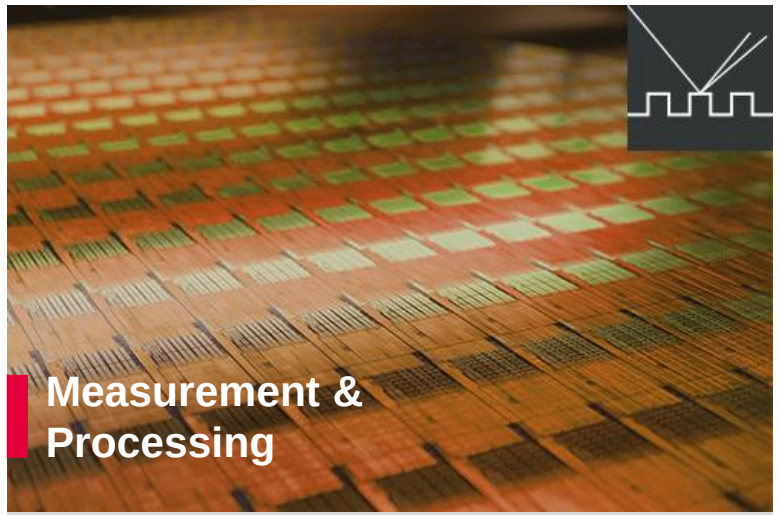
TOPTICA Photonics: Markets for our Laser Products



Biophotonics & Microscopy

- Confocal Microscopy
- Multiphoton Microscopy
- Raman Microscopy
- Optogenetics
- Neuroscience
- Ophthalmology
- Flow Cytometry
- High Throughput Screening



Measurement & Processing

- Metrology
- Semicon Inspection
- Interferometry
- Holography / AR / VR
- Terahertz Spectroscopy
- Non-destructive Testing
- Gas Sensing
- Multiphoton Lithography
- Material Processing

Quantum Technologies & Spectroscopy

- Quantum Computing
- Quantum Simulation
- Quantum Sensing
- Quantum Communication
- Cold Atoms, Laser Cooling
- Bose-Einstein Condensation
- Rydberg Excitation
- Optical Clocks
- Frequency Comb Spectroscopy

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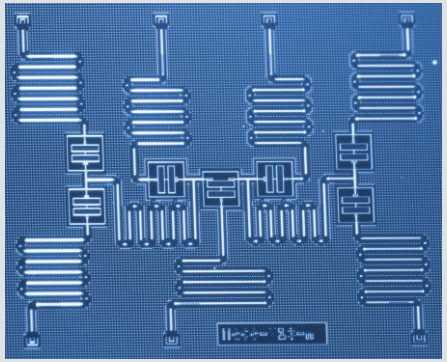
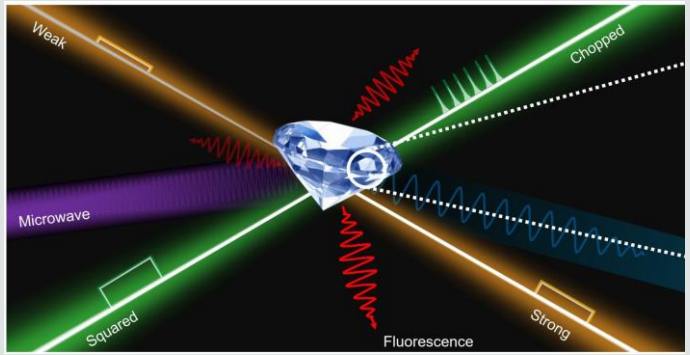
Qubit Systems for Quantum Computing

Superconducting systems



IBM

Color centers in solids

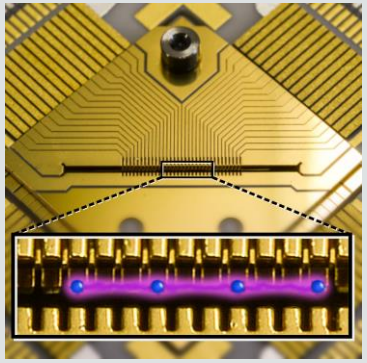


XIE Tianyu USTC

Photonic devices

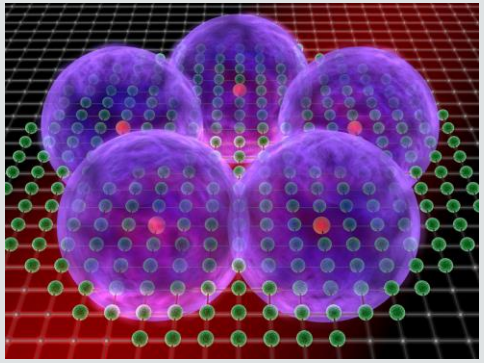
Xanadu

Ion trap systems



QUANTUM Mainz/Thomas Ruster

Neutral atoms



MPI of Quantum Optics

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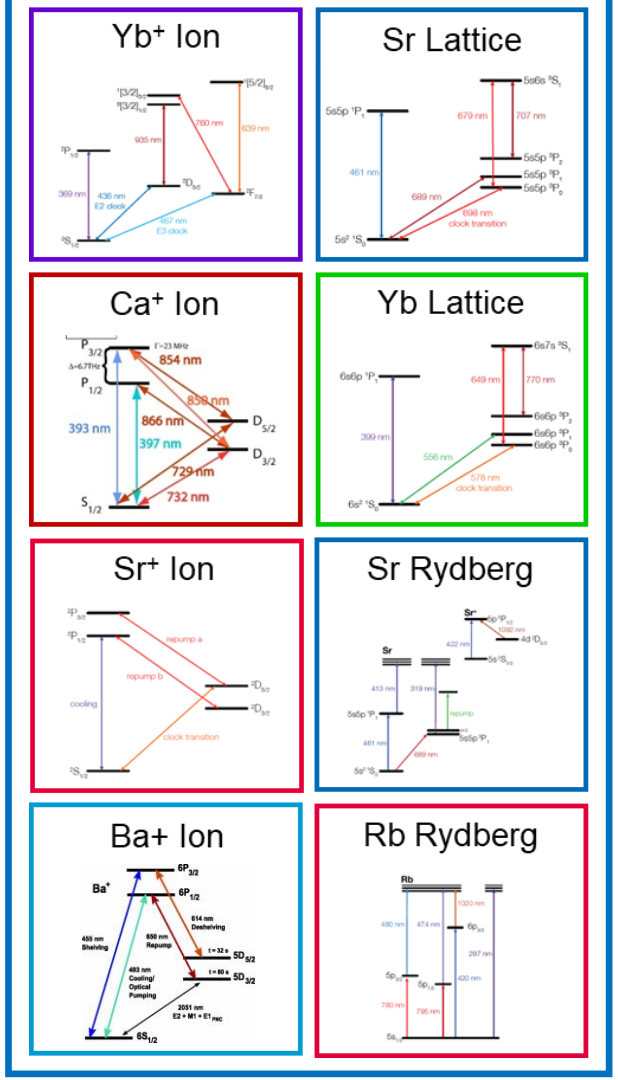
Laser Requirements for Ion and Neutral Atom QuBit Systems

Exemplary QuBit Systems



Requirements to Laser Systems:

- **Wavelength:** Many, almost all!
- **Power:** mW .. few W
- **Frequency stability:** Hz .. MHz
- **Linewidth:** Hz .. MHz
- **Phase noise:** ultralow for gate lasers
- **Convenient control**

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TOPTICA‘s Laser Solutions for Ion and Neutral Atom QuBit Systems

All Wavelengths.
190 nm - 0.1 THz

Highly Coherent Tunable Diode Laser Systems

- Non-amplified
- Amplified
- Frequency doubled / quadrupled

High-Power Amplifiers

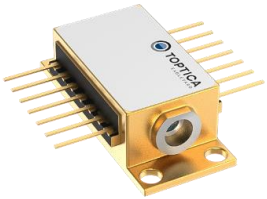
Stable Frequency Reference Systems

- Wavelength Meter
- Spectroscopy Cell
- Frequency Comb
- Ultrastable Laser

Complete Laser System Solutions

- 19“ Rack-mounted & fiber coupled (330 nm to 1770 nm)
- Highly modular
- Fully integrated & frequency stabilized
- Full remote control & user-friendly

Miniaturization



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Laser System Solution for Sr Rydberg Neutral Atom Quantum Computer

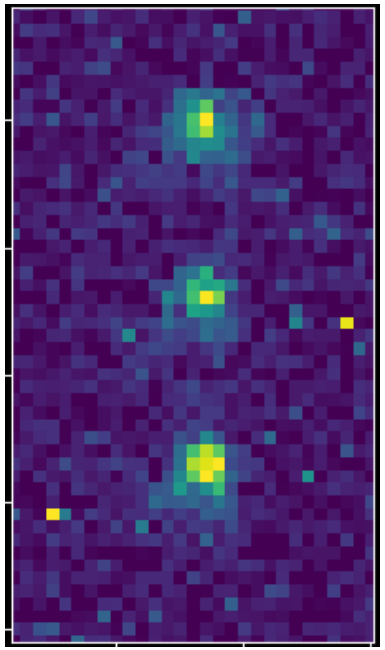
λ [nm]	Type*)	Locked to
317	ECDL-FHG	Optical frequency comb
323	ECDL-FHG	Optical frequency comb
408	ECDL	Wavelength meter
461	ECDL	Optical frequency comb
540	ECDL-SHG	Wavelength meter
592	ECDL-SHG	Wavelength meter
665	ECDL	Optical frequency comb
673	ECDL	Optical frequency comb
679	ECDL	Wavelength meter
688	ECDL	Optical frequency comb
689	ECDL	Optical frequency comb
690	ECDL	Optical frequency comb
698	ECDL	Ultrastable cavity
707	ECDL	Wavelength meter
717	ECDL	Wavelength meter
1550	FL	GPS

16 laser systems!

German government funded project
QRydDemo, University of Stuttgart

Complete Laser System Solution

- Lasers for repumping, autoionization detection and tweezers are locked to wavelength meter
- Lasers for cooling and Qubits are locked to f_{ceo}-free optical frequency comb
- Optical difference frequency comb is locked to an ECDL which in turn is locked to an ultrastable high finesse cavity (narrowing comb teeth to 1-10 Hz linewidth)



Atoms trapped by optical tweezers

Courtesy to Tilman Pfau, University of Stuttgart

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Exciting Times for Photonics for Quantum Computers!

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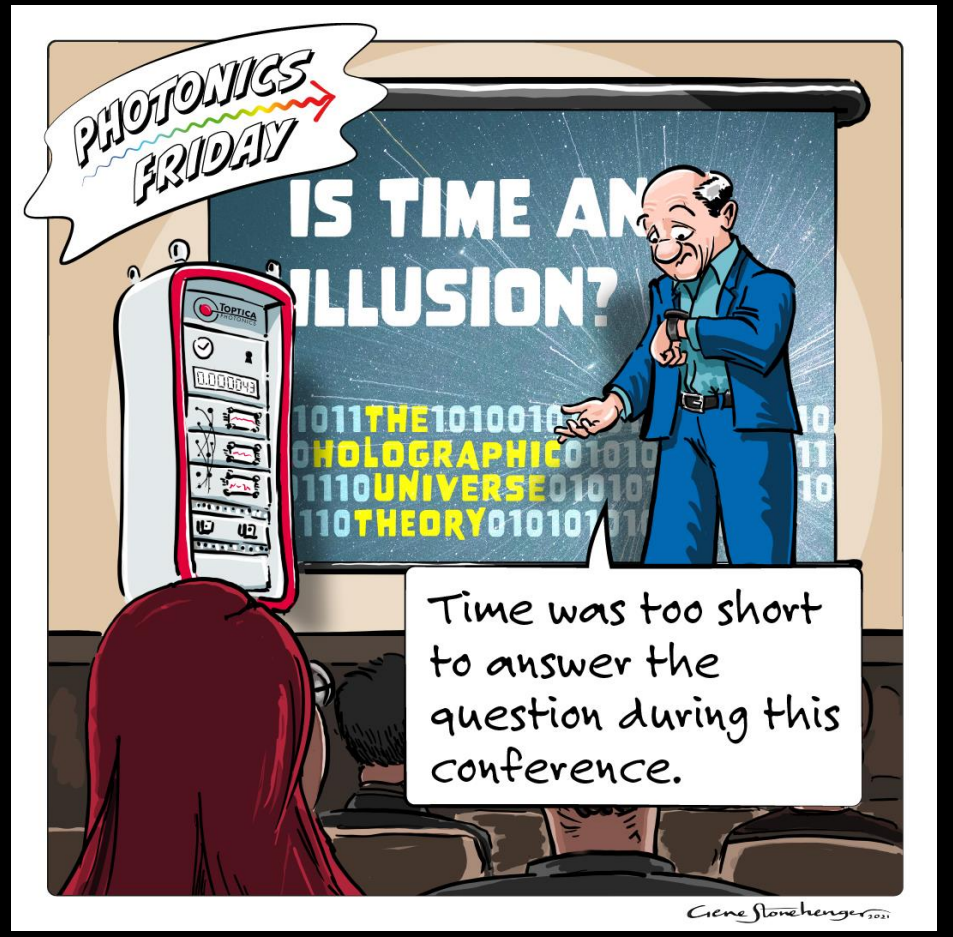

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