Enabling Quantum Precision: Advanced Laser Solutions for Next-Gen Quantum Technologies

HÜBNER Photonics

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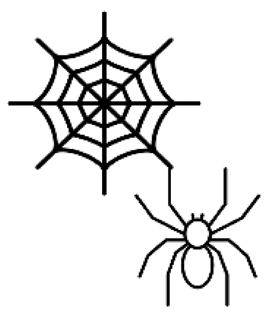
Introduction

Quantum technologies are rapidly advancing, creating a surge in demand for high-performance laser systems crucial for manipulating and controlling quantum states. Lasers serve as the backbone for many quantum processes, from atom trapping and cooling to quantum state manipulation in computing. Quantum applications require lasers with extraordinary specifications, such as exceptional stability, spectral purity, low noise, and precise tunability, to maintain coherence and accuracy in highly sensitive quantum environments. These requirements pose unique engineering challenges and are critical for enabling the reliable and precise operations that quantum technologies depend upon.

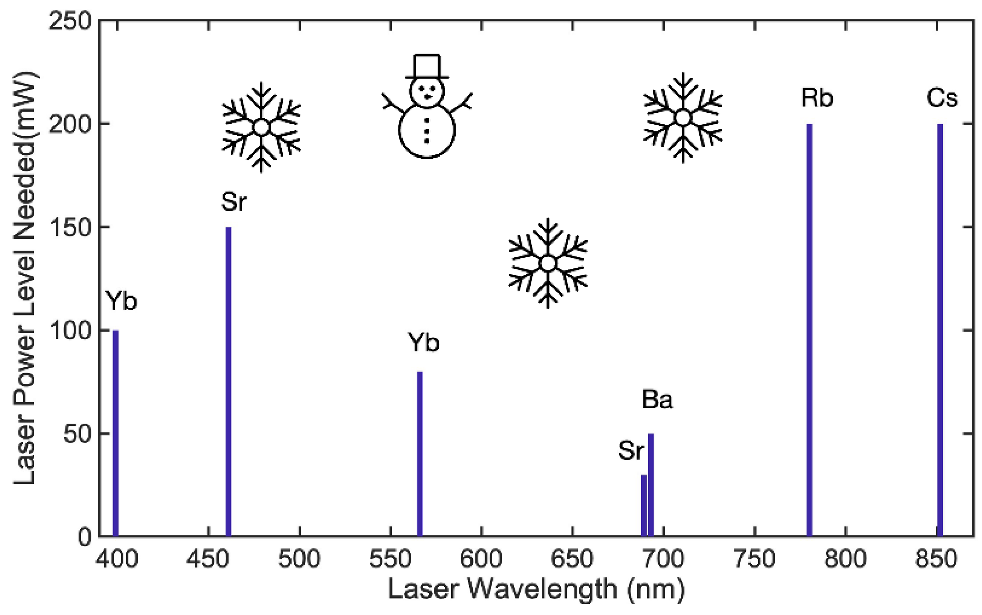
Lasers in Quantum Computing

Lasers used for trapping



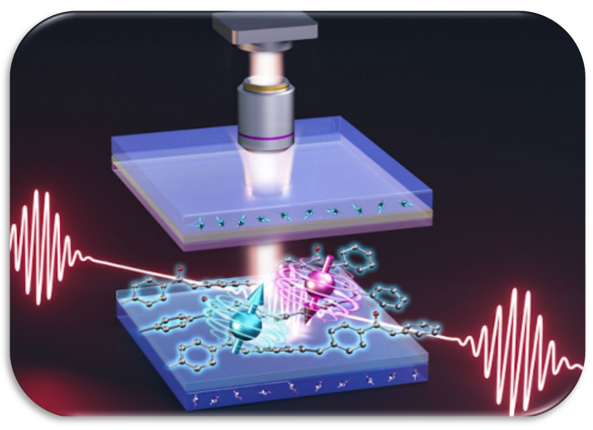
1064 nm Power Level: 5 - 50 W
Rb, Cs, Na, Yb, Sr, Ca, Ba, K, Dy
532 nm Power Level: 1-3 W
Ba, Dy
1070 nm Power Level: 1-5 W
Li

Lasers used for cooling



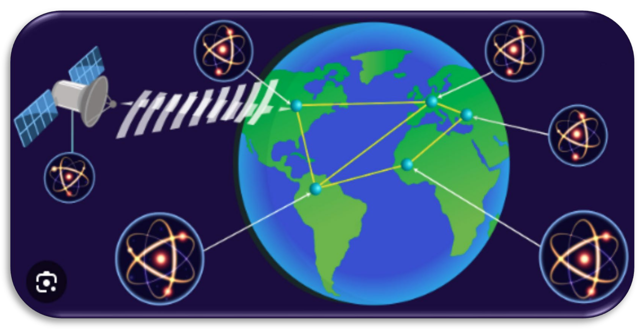
Quantum Technologies

Quantum Sensing



Quantum sensing harnesses unique quantum properties to achieve ultra-sensitive measurements of magnetic fields, electric fields, temperature, and time. Lasers play a pivotal role in quantum sensing, especially in systems like **nitrogen-vacancy** (**NV**) centers in diamond, where they initialize and read out NV spin states: green laser light excites the NV center, while shifts in emitted fluorescence reveal changes in nearby magnetic or electric fields. Similarly, lasers are crucial in atomic magnetometers and optical atomic clocks, where they precisely control and measure atomic states. These laser-enabled quantum sensors offer unprecedented sensitivity, with applications in materials science, biomedical imaging, and precision navigation.

Quantum Communication



Quantum communication leverages quantum mechanics to securely transmit information, primarily using **spontaneous parametric down-conversion (SPDC)** to generate entangled photon pairs. These entangled states enable secure communication methods like quantum key distribution (QKD), ensuring that any eavesdropping attempts are detectable due to the properties of quantum measurements. Additionally, single-photon detectors (SPDs) are utilized to measure and verify the quantum states of the photons, further enhancing communication security.

Quantum Computing

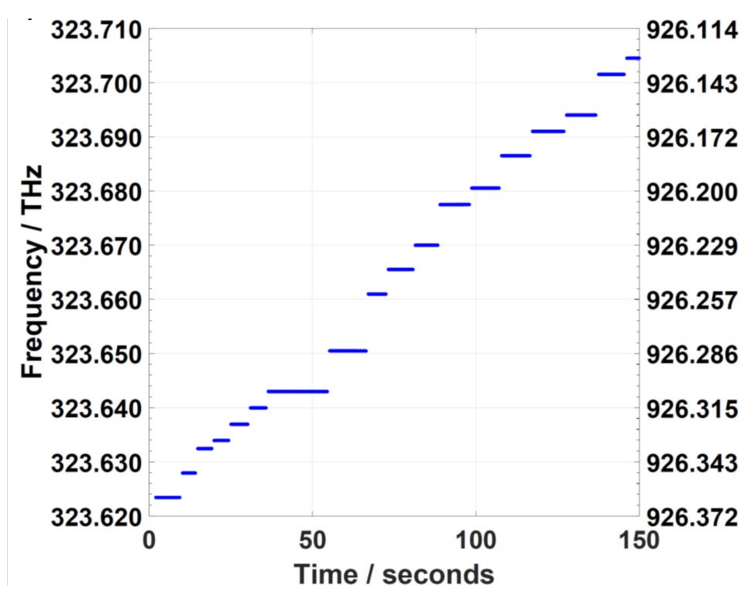
Quantum computing uses ***qubits***, which can exist in multiple states simultaneously and be entangled, enabling powerful parallel processing beyond classical bits. Different types of qubits bring unique strengths: photon-based qubits excel in secure communication, superconducting and nanowire-based qubits provide high-speed processing, and atom- or ion-based qubits—such as those involving trapped rubidium or barium atoms- or ions—use laser sources extensively to achieve high precision and long coherence times for reliable computations.
Together, these approaches are driving the development of scalable, robust quantum computers.

C-WAVE | The tunable laser light source

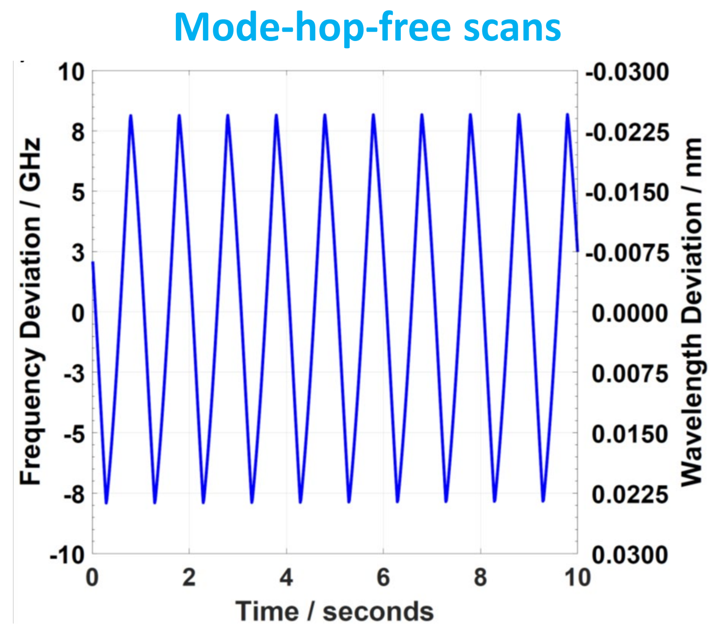
The C-Wave laser series, leveraging continuous-wave OPO technology, provides unmatched wavelength coverage and precise tuning capabilities, ideal for quantum technology research.
This flexibility allows seamless adaptation to evolving experimental requirements, making C-Wave a versatile choice for applications involving novel single-photon emitters and advanced quantum systems.

Tuning Performance

Precision frequency control

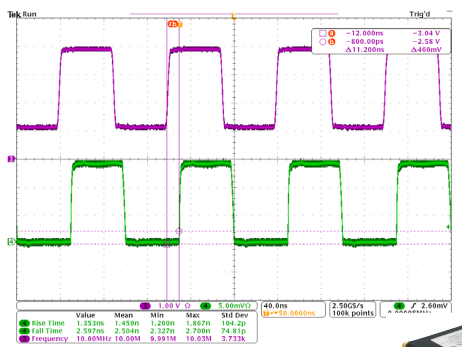


Mode-hop-free scans



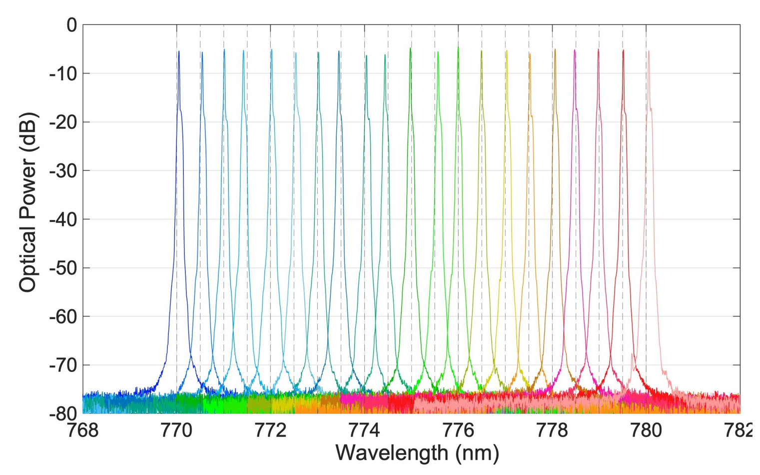
Cobolt 06-01 Series | Fast modulable laser diodes

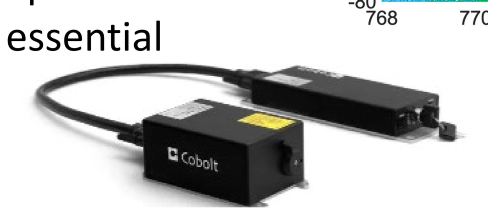
The fast switching (<2.5 ns), high intensity stability (<0.1% rms), and excellent beam quality (TEM00, M² < 1.2) make it ideal for quantum applications requiring precise control and coherence.
With on-off TTL control, complete dark state suppression (>60 dB), and a broad wavelength range (405–930 nm), it offers the stability and flexibility essential for advanced quantum experiments.



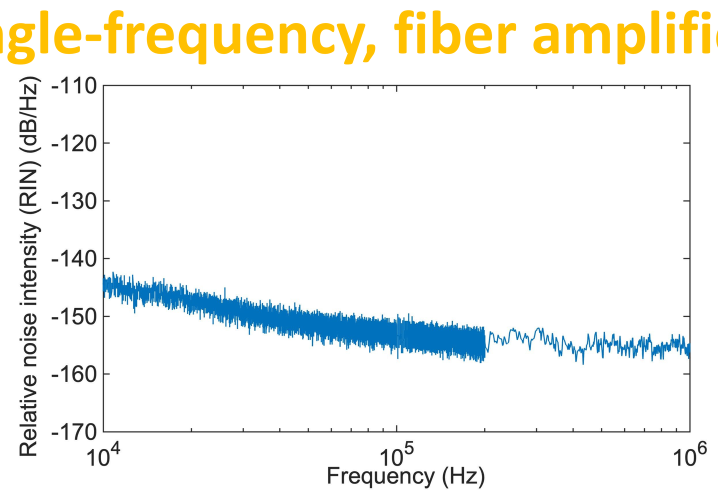
Qu-T™ Series | Compact tunable lasers

The Qu-T laser series is ideal for quantum applications, offering wavelength flexibility, high output power, and exceptionally narrow linewidth (<100 kHz) for precise quantum state manipulation. With high spectral purity, gap-free coarse tuning, and mode-hop-free fine tuning, Qu-T lasers provide stable, accurate, and reliable performance essential for demanding quantum experiments.





Ampheia™ Series | Ultra-low noise, single-frequency, fiber amplifiers



The ultra-low relative intensity noise (RIN), near-perfect beam quality and an optical signal-to-noise ratio (OSNR) exceeding 60 dB at 50 W output power, Ampheia™ provides the high stability and coherence essential for applications like atom trapping, cooling, and quantum state manipulation.

SUMMARY

The advancement of lasers with unparalleled specifications is essential to unlocking the full potential of quantum technologies.

Laser systems designed with ultra-low noise, narrow linewidths, and robust tunability allow for precise control over atomic transitions and quantum states, meeting the high standards required for applications in quantum computing, sensing, and atomic manipulation. Continued development of these high-specification lasers will not only enhance stability and accuracy in quantum experiments but also pave the way for future breakthroughs, making scalable, high-performance quantum technologies a reality.

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