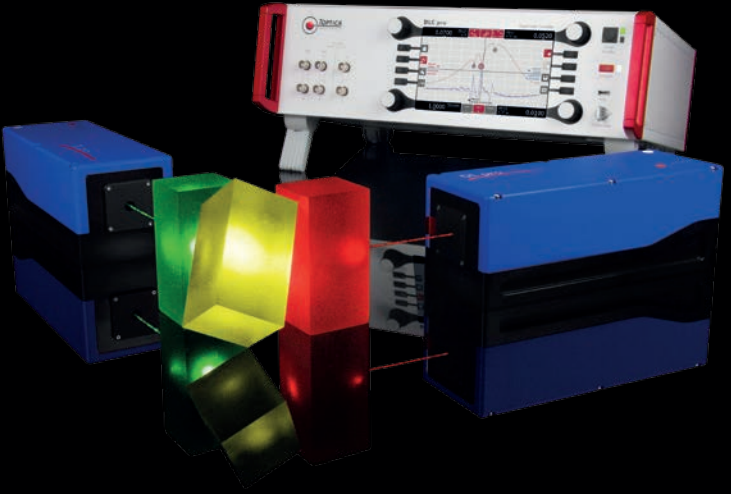
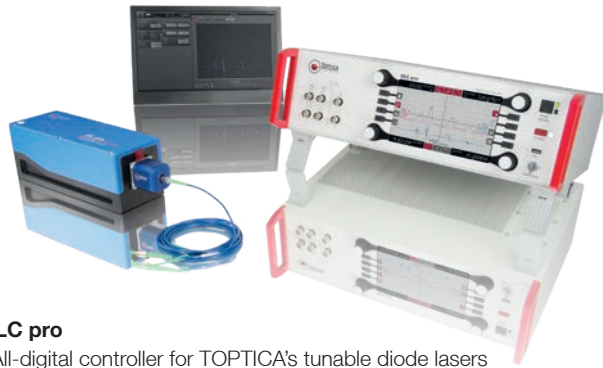


Solutions for Optical Clocks

Diode Lasers, Frequency Combs & Electronics



Tunable Diode Laser Systems



DLC pro

- All-digital controller for TOPTICA's tunable diode lasers
- Extremely low noise and precise control
- Convenient dials & multi-touch user interface
- Includes computer control program and Python support
- Includes active power stabilization
- Software option enables intelligent frequency locking features

(M)DL pro

- Extended Cavity Diode Laser (ECDL)
- Ultra-stable patented resonator design (DE 10 2007 028 499 and US 7970024)
- Optimized virtual pivot point
- Convenient alignment-free coarse-tuning from outside the laser head
- Fast current AC & DC modulation with protection
- At some wavelengths high power available with DL pro HP
- DLC DL pro = DL pro + DLC pro

(M)TA pro

- MOPA system with DL pro seed laser (see above) and tapered amplifier in one laser head
- Powers up to 4000 mW
- Excellent beam quality: typical $M^2 < 1.5$
- DLC TA pro = TA pro + DLC pro

Frequency Converted Diode Lasers



(M)SHG pro

- TA pro diode laser + SHG pro second harmonic generator in one box
- UV, blue, green, yellow or red wavelength
- Up to 2000 mW output power* (depends on wavelength)
- PowerLock included, AutoAlign included in MSHG pro
- Up to 20 nm coarse tuning (wavelength dependent)
- (Raman) Fiber amplifier available for higher output powers*
- Without amplification stage available as DL-SHG pro
- With DLC pro: DL/TA-SHG pro

TA-FHG pro

- TA pro diode laser + two subsequent second harmonic generators SHG pro in one box
- At DUV wavelengths Super UV (SUV) version available for more power and increased lifetime
- Wavelength in the UV region
- Up to 700 mW output power available (depends on wavelength)
- PowerLock included, AutoAlign optional
- 1 nm .. 4 nm coarse tuning (wavelength dependent)
- (Raman) Fiber amplifier available for higher output powers
- Without amplification stage available as DL-FHG pro
- With DLC pro: DL/TA-FHG pro

* higher output power available with fiber amp solutions

DFC - Difference Frequency Combs



Compact, Robust, High-end and Convenient

- Comb spacing: 80 MHz or 200 MHz
- Stability: $8 \cdot 10^{-18}$ in 1 s^* , $5 \cdot 10^{-20}$ in 1000 s^*
- Accuracy: $1 \cdot 10^{-18}$ for $\tau > 100 \text{ s}^*$
- Integrated phase noise f_{CEO}^* : $< 65 \text{ mrad}$ [70 MHz - 20 MHz]
- Linewidth: $< 1 \text{ Hz}$ (locked to optical reference)
- Wavelength coverage 420 - 2200 nm

Convenient

- Control everything from a single window



DFC LOCK UNIT: PFD & FALC

- Robust phase and frequency lock
- Remote control and locking
- Convenient Software interface with DFC
- Tunable RF source for offset generation
- Beat signal conditioning
- 10 MHz reference input



T-RACK - Laser Rack Systems

All Wavelengths.

More Power.

Maximum Modularity.

- Highly modular rack integration of modular laser systems and units MDL pro, MTA pro, MSHG pro, MDFC, MOM, Wavelength Meter, and locking electronics
- Broad wavelength coverage 330 .. 1625 nm with output power up to 2W ex fiber
- Fiber coupled and polarized optical output
- Convenient remote control
- Industry-grade appearance and operation



Locking Electronics

All systems may be combined with versatile and high performance frequency locking solutions:

DLC pro Lock

Versatile locking option built into DLC pro

- two feedback channels with independent PIDs
- side-of-fringe and top-of-fringe locking

FALC pro

Fast Analog Linewidth Controller

- Digitally controlled fast laser locking module
- PI^2D^2 regulator
- 10 ns delay

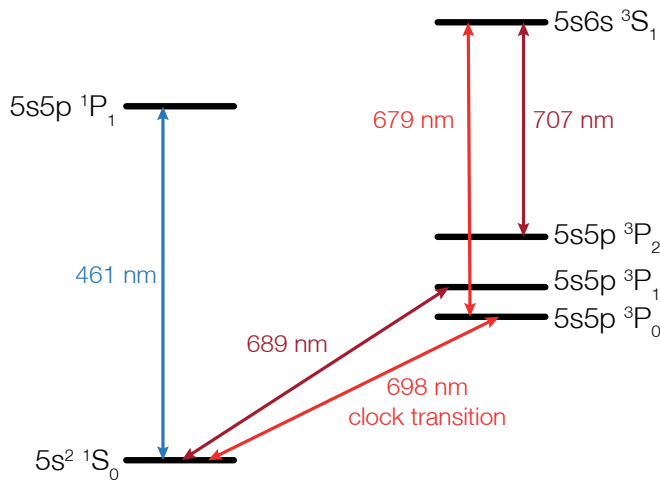
PDH/DLC pro

Pound-Drever-Hall Detector

- generates dispersive error signal via modulation/demodulation
- two channels

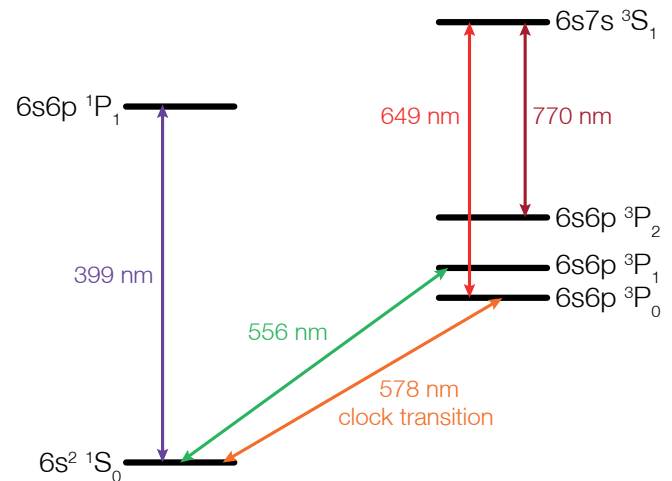


Strontium Lattice Clock



| | Wavelength | Product | Power | Comb extension |
|-------------------------------------|------------|--|----------|----------------|
| Strong cooling | 461 nm | DLC TA-SHG pro Sr cooling | 1300 mW | DFC SCNIR |
| Strong cooling | 461 nm | DLC DL pro HP 461 | 250 mW | DFC DVIS |
| Narrow cooling | 689 nm | DLC DL pro, narrow linewidth option | 25-35 mW | DFC DVIS |
| | | DLC TA pro, narrow linewidth option | 200 mW | DFC DVIS |
| Clock | 698 nm | DLC DL pro, narrow linewidth option | 25-35 mW | DFC DVIS |
| Clock for SHG, TOPTICA exclusive | 1397 nm | DLC DL pro, narrow linewidth option | 80 mW | DFC SCIR |
| Optical lattice | 813 nm | DLC TA pro | 3000 mW | DFC DVIS |
| Optical lattice | 813 nm | DLC DL pro | 60 mW | DFC DVIS |
| Repump | 679 nm | DLC DL pro | 45 mW | DFC DVIS |
| Repump | 707 nm | DLC DL pro | 25 mW | DFC DVIS |

Ytterbium Lattice Clock

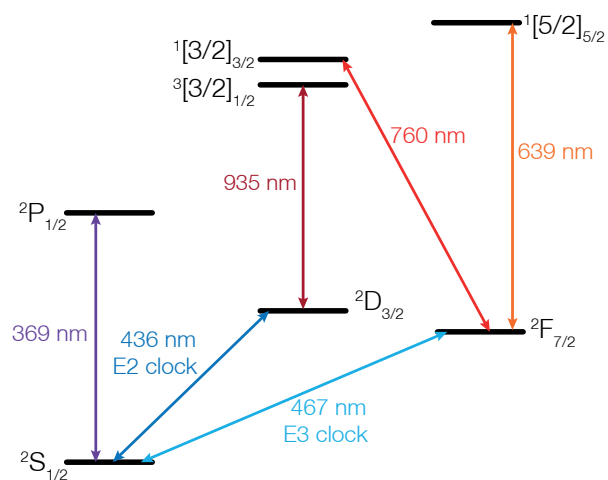
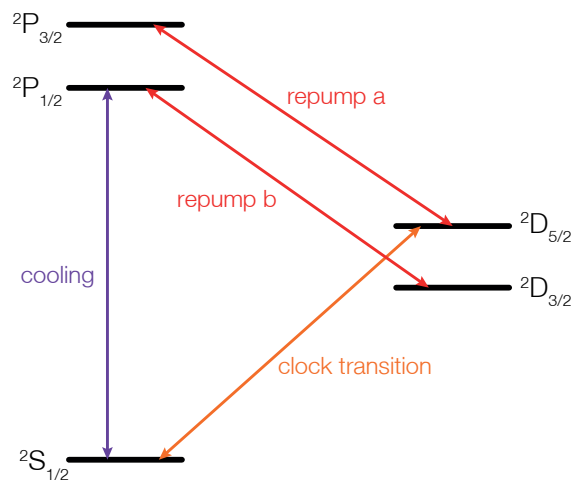


| | Wavelength | Product | Power | Com extension |
|-----------------|------------|--|---------|---------------|
| Strong cooling | 399 nm | DLC TA-SHG pro | 1500 mW | DFC NIR |
| Strong cooling | 399 nm | DLC DL pro HP 399 | 110 mW | - |
| Narrow cooling | 556 nm | DLC Ytterbium Cooling | 2000 mW | DFC SCIR |
| Clock | 578 nm | DLC DL-SHG pro, narrow linewidth option | 10 mW | DFC SCIR |
| Clock for SHG | 1156 nm | DLC DL pro, narrow linewidth option | 80 mW | DFC SCIR |
| Optical lattice | 759 nm | DLC TA pro | 1500 mW | DFC DVIS |
| Optical lattice | 759 nm | DLC DL pro | 100 mW | DFC DVIS |
| Repump | 770 nm | DLC DL pro | 80 mW | DFC NIR |
| Repump | 649 nm | DLC DL pro | 15 mW | DFC DVIS |

TOPTICA also provides lasers for other optical clocks that are not shown here. This includes optical lattice clocks based on mercury or magnesium, ion clocks with mercury, barium or indium and quantum logic clocks based on an aluminium ion. Special solutions are available upon request.

Calcium & Strontium Ion Clock

Ytterbium Ion Clock



| Calcium ion | Wavelength | Product | Power | Comb extension |
|---|------------|--|--|----------------|
| Ionization 1 st step | 423 nm | DLC DL pro HP 420 | 70 mW | DFC DVIS |
| Ionization 2 nd step | 375 nm | iBeam smart 375 | 70 mW | - |
| Cooling | 397 nm | DLC TA-SHG pro Ca ⁺ Cooling | 1500 mW | DFC NIR |
| Cooling | 397 nm | DLC DL pro HP 397 | 65 mW | - |
| Repump a | 854 nm | DLC DL pro 850 | 70 mW | DFC SCNIR |
| Repump b | 866 nm | DLC DL pro 850 | 70 mW | DFC SCNIR |
| Clock | 729 nm | DLC DL pro, narrow linewidth option | 40 mW | DFC DVIS |
| Subrack providing 423 nm, 397 nm, 854 nm and 866 nm | | DLC MDL pro Ca ⁺ | For details see www.toptica.com/MDL | |
| Strontium ion | | | | |
| Ionization 1 st step | 461 nm | DLC DL pro HP 461 | 250 mW | DFC DVIS |
| Ionization 2 nd step | 405 nm | iBeam smart 405 | > 100 mW | - |
| Cooling | 422 nm | DLC TA-SHG pro | 800 mW | DFC DVIS |
| Cooling | 422 nm | DLC DL pro 420 | 70 mW | DFC DVIS |
| Repump a | 1033 nm | DLC DL pro | 200 mW | DFC SCIR |
| Repump b | 1092 nm | DLC DL pro | 100 mW | DFC SCIR |
| Clock | 674 nm | DLC DL pro, narrow linewidth option | 30 mW | DFC DVIS |
| Clock via SHG | 674 nm | DLC DL-SHG pro | 2 mW | DFC-SCIR |

| | Wavelength | Product | Power | Comb extension |
|---|------------|---|--|----------------|
| Ionization 1 st step | 399 nm | DLC DL pro HP 399 | 110 mW | - |
| Cooling and ionization 2 nd step | 369 nm | DLC TA-SHG pro Yb ⁺ Cooling | 80 mW | DFC DVIS |
| Cooling and ionization 2 nd step | 369 nm | DLC DL pro HP 369 | 13 mW | - |
| Repump | 935 nm | DLC DL pro | 100 mW | DFC SCNIR |
| Clock | 436 nm | DLC DL SHG pro | 5 mW | DFC SCNIR |
| Clock via SHG | 871 nm | DLC DL pro | 90 mW | DFC SCNIR |
| Repump | 760 nm | DLC DL pro | 100 mW | DFC DVIS |
| Repump | 639 nm | DLC DL pro | 25 mW | DFC DVIS |
| Clock via SHG | 467 nm | DLC DL-SHG pro, narrow linewidth option | 10 mW | DFC DVIS |
| Clock for SHG | 934 nm | DLC DL pro, narrow linewidth option | 120 mW | DFC SCNIR |
| Subrack providing 399 nm, 369 nm, 935 nm and 760 nm | | DLC MDL pro Yb ⁺ | For details see www.toptica.com/MDL | |



For laser classifications and further safety information concerning the mentioned laser products please refer to our product catalogs and our website.

TOPTICA is active partner in clock-related projects:

opticlock Optical Single Yb Ion Clock,

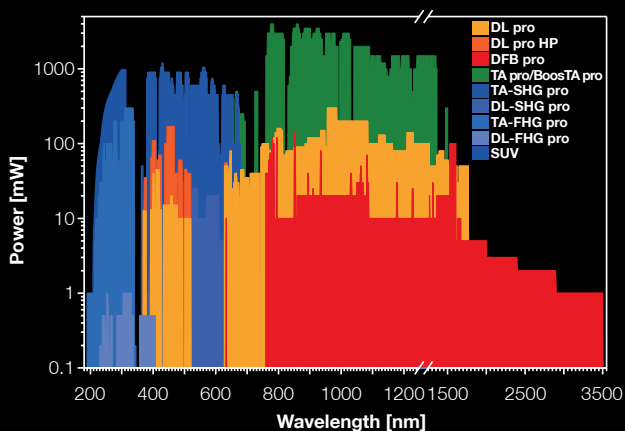
BMBF: QUTEQA - www.opticlock.de

iqClock Integrated Quantum Clock,

EU: Horizon 2020 - www.iqclock.eu



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