High-powEr Phosphorous-based DFB Lasers for Cold Atom Systems (HELCATS)

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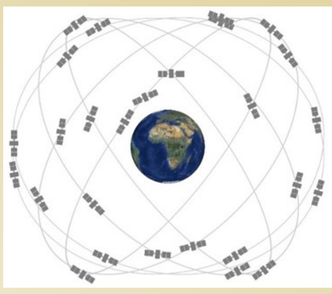
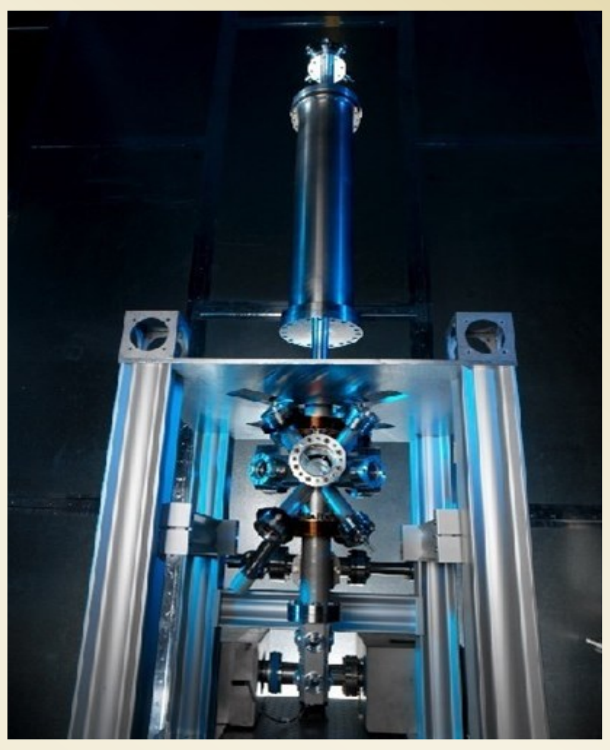
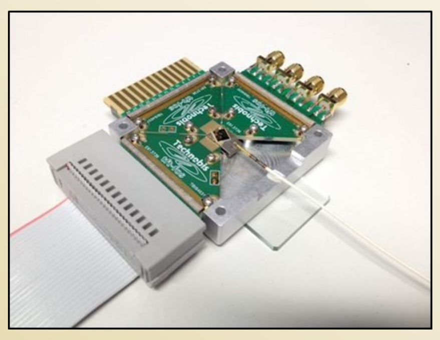
Motivation



- Demand of high precision time references for quantum applications (e.g. GPS navigation, sensing, metrology, etc.)
- Atomic Clocks are bulky and expensive
- Miniaturization and integration of the optical components





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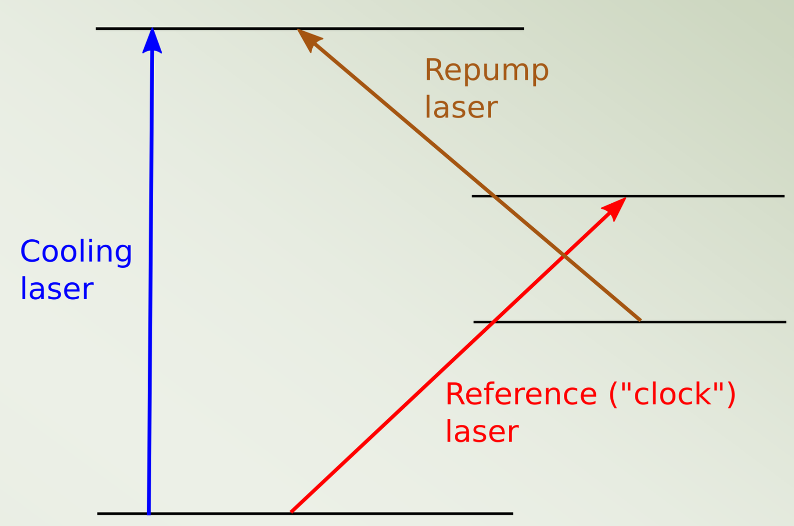
Optical clocks

In a typical atomic clock three lasers are necessary.

- Cooling transitions: 369 nm (^{171}Yt+), 397 nm (^{40}Ca+), 422 nm (^{88}Sr+), 461 nm (^{87}Sr), 689 nm (^{87}Sr)
- Repump transitions: 638 nm (^{171}Yt+), 679 nm (^{87}Sr), 707 nm (^{87}Sr), 866 nm (^{40}Ca+)
- Clock transitions: 467 nm (^{171}Yt+), 674nm (^{88}Sr+), 698 nm (^{87}Sr), 729 nm (^{40}Ca+)

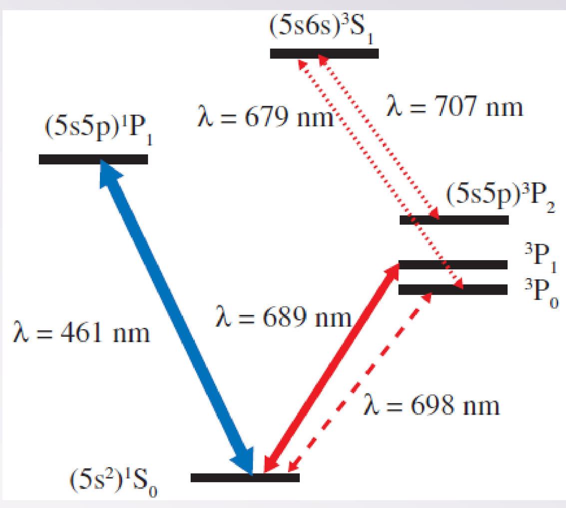


III-V semiconductor lasers offer reduced fabrication cost, low energy consumption and on-chip integration.

GaAs/AlGaAs platform covers a wide range of wavelength, i.e. 700-900 nm, which contains several optical clock transitions.

^{87}Sr optical lattice clock

The ^{87}Sr optical clock using lattice-confined atoms offers one of the most accurate reference with a systematic uncertainty in the order of 10^{-16}, comparable to the primary Cs standard.

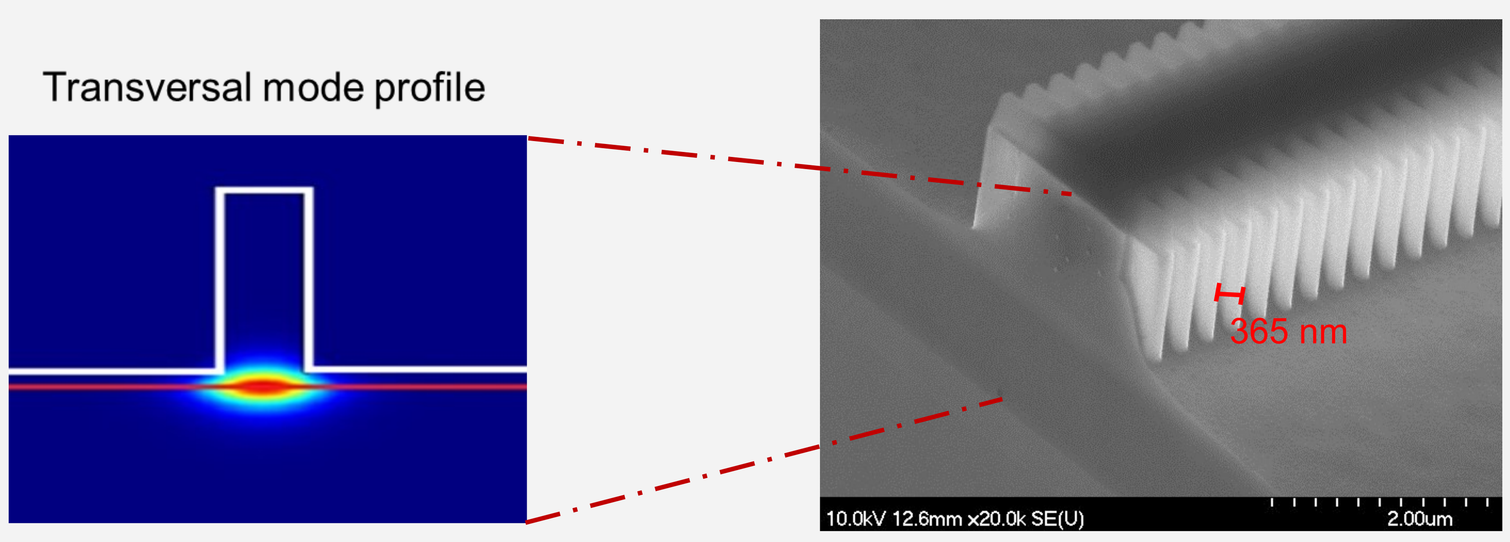


The wavelengths of interest for ^{87}Sr optical lattice clocks are in the 680-710 nm range:

- 679 nm: Sr repump (Power > 10 mW, linewidth < MHz)
- 689 nm: Sr 2nd cooler (Power > 10 mW, linewidth < MHz)
- 698 nm: Sr clock (Power > 100 mW, linewidth < MHz)
- 707 nm: Sr repump (Power > 10 mW, linewidth < MHz)

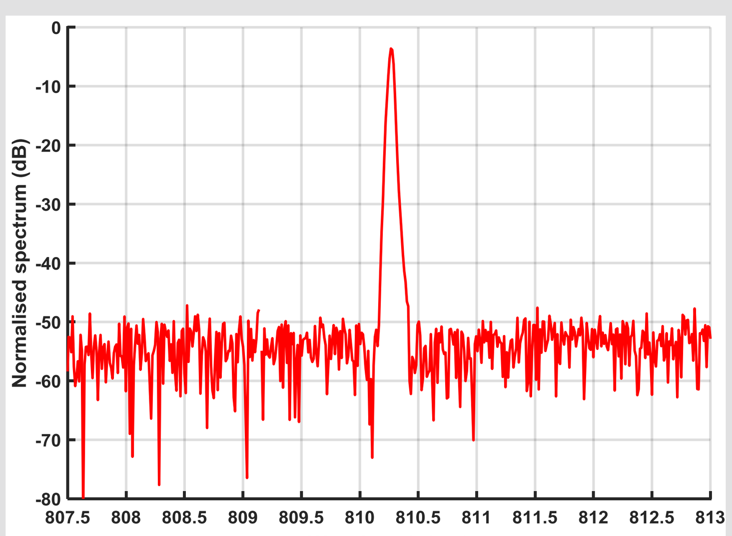
Sidewall distributed feedback (DFB) lasers

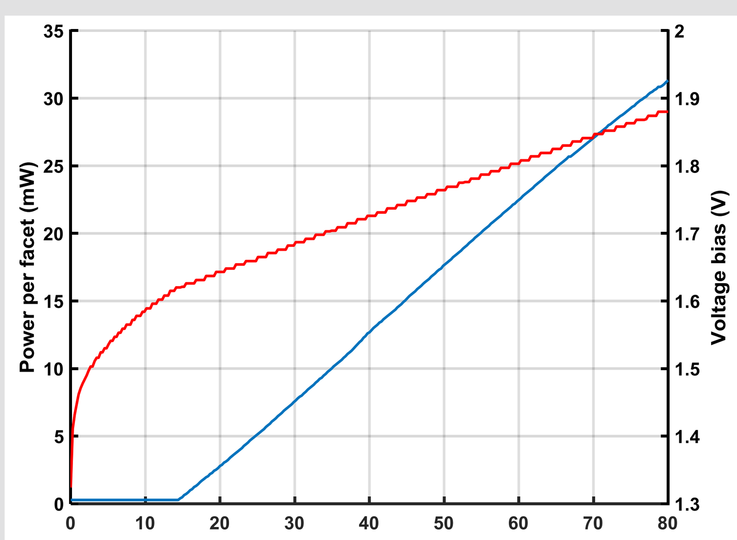
- Longitudinal single-mode operation with very high suppression ratio (SMSR)
- Excellent wavelength accuracy and emission linewidth thanks to Bragg grating technology



Single-mode DFB lasers at 813 nm wavelength

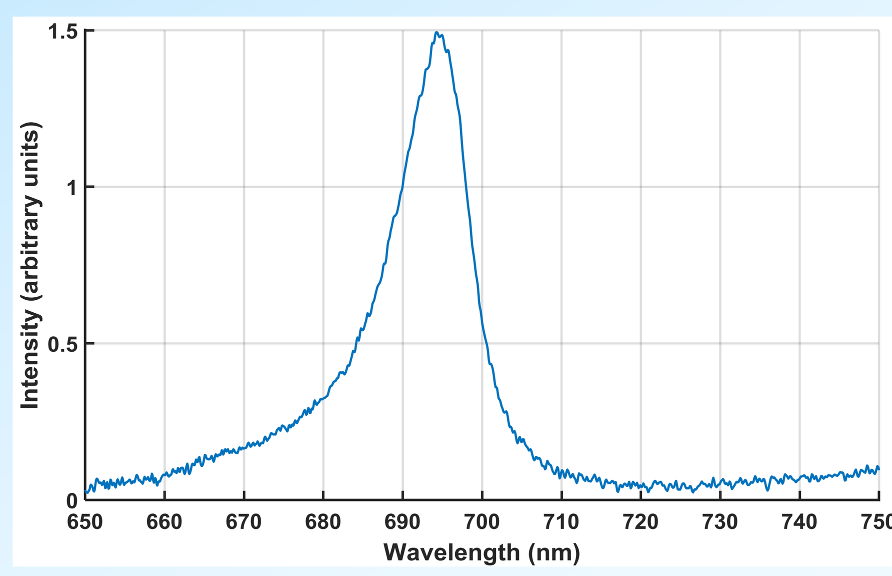
- Single-mode with SMSR approaching 50dB
- Power output exceeding 30 mW per facet
- Current threshold as low as 12.5 mA





Emission in the 680-710 nm wavelength range

- Design and growth of AlGaAs/InGaP epilayers on GaAs substrate
- Photoluminescence spectrum exhibits material gain in the 680-710 nm wavelength range



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References

[1] Y. Wang, X. Lu, B. Lu and H. Chang (2018) "Recent Advances Concerning the 87Sr Optical lattice Clock at the National Time Service Centre", Applied Sciences, Vol. 8, No. 11, pp. 2194-2203