

# Portable Dual-Wavelength Optical Atomic Rubidium Clock

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Modern society is critically dependent upon stable timing signals typically disseminated by global navigation systems such as GPS, but the highest degree of timing accuracy is afforded by laboratory-based primary frequency standards [1]. The trade-off between clock frequency stability and Size, Weight and Power (SWaP) is the subject of intense research, with high-performance portable clock systems a necessity for a large array of real-world applications and in GPS-denied environments [2].

We report progress on the development and out-of-lab demonstrations of a next-generation optical timing reference based on the dual-wavelength excitation of the  $5S_{1/2} \rightarrow 5D_{5/2}$  two-photon transition of rubidium-87 [3, 4]. This work aims to develop a commercial portable frequency reference that has greatly improved frequency stability over the best commercially available technologies. We make use of the robustness of mature laser telecommunications technologies, FPGA-based control systems and automation, and a compact optical frequency comb to generate stable clock outputs in the optical (778nm, 385THz) and radio frequency (1GHz) domains for interfacing with both optical systems and conventional electronics [5]. We have measured fractional frequency instability of the rubidium clock of  $1.5 \times 10^{-13}$  at 1s, integrating down at  $1/\sqrt{\tau}$  to  $3 \times 10^{-15}$  at 8,000s.

Variants of this clock architecture have operated successfully in harsh out-of-lab environments including onboard a moving van and for several weeks operating autonomously on the deck of a large maritime vessel during active sea trials. The clock is currently being developed for space operations.

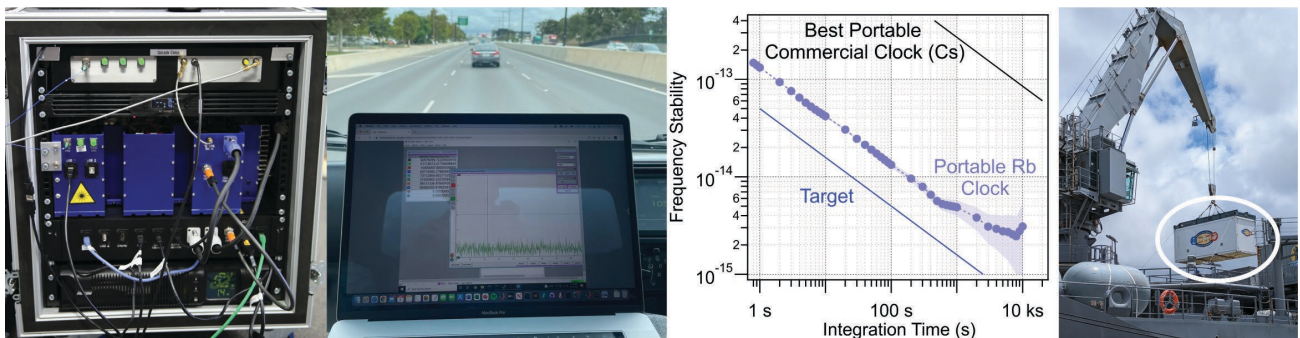


Fig. 1. Left to right: 19" rack mounted portable Rb clock held within 11 rack units (11U); readout of clock during operation in vehicle; Clock performance of  $1.5 \times 10^{-13}$  at  $\tau = 1$ s, integrating down at  $1/\sqrt{\tau}$  to  $3 \times 10^{-15}$  at 8,000s, clock loading onto HMNZS Aotearoa (within shipping container, circled) prior to naval exercises.

## References

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