Development & Performance of a Portable Dual-Colour Two-Photon Rb Clock

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The highest degree of timing accuracy is afforded by laboratory-based primary frequency standards [1], however portable atomic clock systems are a necessity for a large array of real-world applications including communication and satellite-guided navigation [2]. The development of laser-driven optical atomic clocks promises a much higher inherent stability proportional to their operating frequency as compared to their microwave counterparts [3]. Further, the development of miniaturised optical frequency combs [4], has allowed optical clocks to produce RF signals suitable for interfacing with conventional electronics.

Utilising mature commercially-available telecommunications technologies and the $5S_{1/2} \rightarrow 5D_{5/2}$ two-photon transition of rubidium, we demonstrate the first automated, portable, dual-colour two-photon optical rubidium clock. Preliminary results achieve fractional frequency instabilities of $1.3 \times 10^{-13}/\sqrt{\tau}$ for $1\text{s} < \tau < 1000\text{s}$, crossing into the 10^{-15} regime at $\tau = 200\text{s}$. The clock features a home-built integrated miniature optical frequency comb [4], FPGA-based control, and autonomous start-up and stabilisation. We report on the development and performance testing of our system both in-lab and out-of-lab. (Fig. 1).

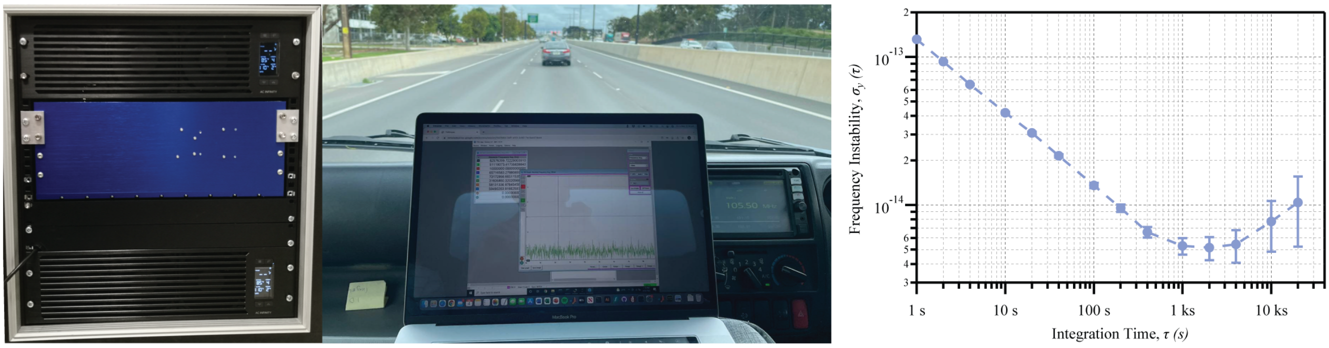

Figure 1: Left: 19" rack-mounted portable Rb clock held within 11 rack units (11U); Middle: readout of clock during operation in vehicle; Right: preliminary clock performance of $1.3 \times 10^{-13}/\sqrt{\tau}$ fractional frequency instabilities up to 1000s.

[1] R. Wynands and S. Weyers, *Metrologica* **42**, S64–S79 (2005).

[2] F. Esnault, N. Rossetto, D. Holleville, J. Delporte, and N. Dimarcq, *Adv. Space Res.* **47**, 854 (2011).

[3] C. Perrella, P. S. Light, J. D. Anstie, F. N. Baynes, R. T. White, and A. N. Luiten, *Phys. Rev. Appl.* **12**, 054063 (2019).

[4] L. C. Sinclair, J.-D. Deschênes, L. Sonderhouse, W. C. Swann, I. H. Khader, E. Baumann, N. R. Newbury, and I. Coddington, *Rev. Sci. Instrum.* **86**, 081301 (2015).