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 $1s < \tau < 1000s$, crossing into the $10^{-15}$ regime at $\tau = 200s$. 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.