A Laser-Cooled Optical Beam Clock

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Microwave beam clocks are found not only in the well-controlled conditions of national laboratories world-wide, but also in GPS satellites and in deployed military environments. At the University of Adelaide, we are investigating the optical analogue of these devices [1,2], and have recently demonstrated an optical beam clock based on the $^1S_0$-$^3P_0$ transition in neutral ytterbium. Our goal is to combine the robust architecture of a beam clock with the improved performance offered by optical transitions to produce a device that can provide high-performance timing capabilities outside of the lab.

Figure 1 (a) and (b) show a schematic and image of the physics package developed for the ytterbium optical beam clock. An in-house designed and constructed oven is used to produce a directional atomic beam, which is then collimated by two transverse cooling stages. A measurement of the 10-mHz wide clock transition is made via Ramsey-Bordé spectroscopy [3] followed by a velocity-selective ground state fluorescence measurement. Figure 1 (c) shows an example clock signal recorded with this physics package (black), with good agreement to our theoretical model (red). Preliminary measurements of the frequency stability of the down-converted [4] 180 MHz clock output show an atom-shot noise limited fractional frequency instability of 10^{-13} at 1s, already competitive with current commercially available portable systems.

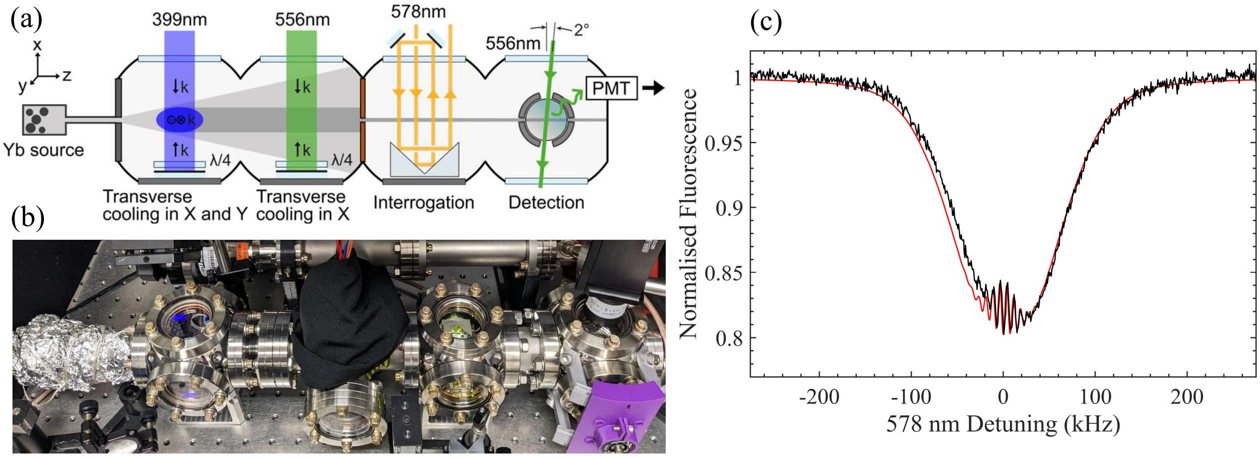

Figure 1: (a) Schematic and (b) image of the atomic beam physics package showing the transverse cooling (first- and second-stage), interrogation and detection stages. (c) Ramsey-Bordé spectroscopy signal (black) and theoretical model (red) for a longitudinal atomic velocity of 95 m/s and rabi frequency of 9 kHz.

References

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