Progress towards a transportable laser-cooled Yb^+ microwave clock

Michael A. Trigatzis, Martin Knapp, Sean Mulholland, Gary I. Hockley, Geoffery P. Barwood, Guilong Huang, Hugh A. Klein, Patrick Gill
Time and Frequency Department, National Physical Laboratory, Teddington, UK
Email: michael.trigatzis@npl.co.uk

Optical atomic clocks based on cold atoms or ions represent the current state of the art in terms of clock stability and accuracy. However, they are difficult to commercialise since they rely on high size, weight, power and cost (SWAP-C) subsystems including optical frequency combs and ultranarrow-linewidth clock lasers. Laser-cooled ion microwave clocks offer performance advantages in long-term frequency stability and reproducibility, in comparison to currently commercially available clocks, without the need for these latter optical subsystems[1,2,3]. Their relative simplicity and high performance make them excellent candidates for applications including navigation and as master clocks in critical national timing infrastructure.

We present recent progress towards building a transportable laser-cooled ion microwave clock. Prior to packaging the clock in its compact housing, the various subsystems are to be tested and their performance validated in a benchtop setup. These subsystems include the ion trap and vacuum package (Figure 1), the magnetic control and shielding system, the laser system, and the electronics, control and microwave system. We present the results of component level testing, as well as initial Ramsey and Rabi spectroscopy of the clock transition at 12.6 GHz.

We acknowledge the support of the UK government department for Science, Innovation and Technology through the UK national quantum technologies program.

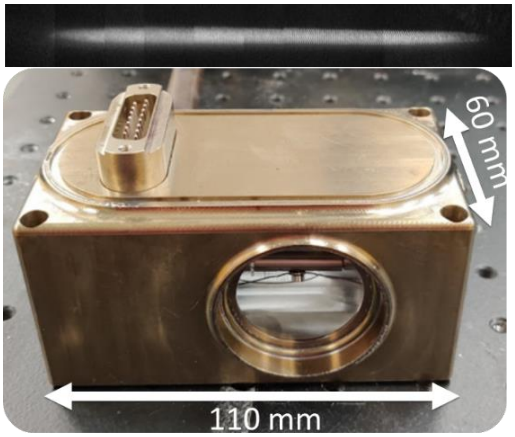

Fig. 1: Coulomb crystal of laser-cooled ions (top) trapped within the vacuum chamber (bottom).

[1] S. Mulholland *et al.*, "Laser-cooled ytterbium-ion microwave frequency standard," *Appl. Phys. B Lasers Opt.*, vol. 125, no. 11, p. 198, 2019, doi: 10.1007/s00340-019-7309-6.

[2] S. Mulholland *et al.*, "Compact laser system for a laser-cooled ytterbium ion microwave frequency standard," *Rev. Sci. Instrum.*, vol. 90, no. 3, 2019, doi: 10.1063/1.5082703.

[3] N. C. Xin *et al.*, "Laser-cooled 171-Yb+ microwave frequency standard with a short-term frequency instability of $8.5 \times 10^{-13}/\sqrt{\tau}$," *Opt. Express*, vol. 30, no. 9, p. 14574, 2022, doi: 10.1364/oe.453423.