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Development of a portable optical atomic clock based on a single Ca+ ion

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Optical clocks are the most accurate time keeping instruments to date. However, widespread use is being prevented by their large size, high cost and high technical complexity of operation. To overcome these hindrances we are developing a compact, turn-key-operation portable optical clock based on trapped single Ca^+ ions. The system fits in a 4 unit 19 inch module box (500x520x160 mm), with a target weight under 20 kg and a target power consumption under 100 W. The expected fractional uncertainty of our system is ˜10^{-16}.
The miniaturisation of the system is made possible by recent developments in optical fibres and optical fibre components. A fibre based compact laser system provides all the necessary frequencies to ionise and laser-cool a Ca^+ ion, which sits inside an endcap Paul trap. Light is delivered onto the ion via polarisation maintaining optical fibres, which make their way into the vacuum chamber eliminating the need for windows. Fluorescence from the ion is collected directly using multimode fibres embedded inside the trap electrode structure, eliminating the need for bulky high NA lenses. The reference laser is stabilised to an ultra-stable optical cavity developed at NPL, and then locked to the Ca^+ quadrupole transition at 729 nm. On-board electronics controlling the various subsystems will provide the necessary intelligence to run the system autonomously, making it a "black box"from the user's perspective. We believe this approach will make our system suitable for integration in a wide variety of environments.

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