Measurements with transportable Sr lattice clocks

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In view of the discussion of a redefinition of the unit second and of applications of optical clocks by users outside highly specialized laboratories, the development of transportable optical clocks is of high relevance. They serve to link optical clocks that cannot be compared by high-performance fibre links or as the foundation of commercial, robust instruments. At PTB, we operate a laboratory-based strontium lattice clock and a transportable one, both targeting fractional uncertainties in the low 10^{-18} range. The setups allow for interrogation of the strontium atoms in a radiation shield that can be cooled and thus reduces the shift induced by thermal radiation (BBR). Here, I will focus on our activities with the transportable setup.

I will discuss a measurement campaign with our first-generation transportable lattice clock, in which we performed chronometric levelling, i.e. a gravity potential difference determination, between Munich and Braunschweig in Germany[1]. The transportable clock was operated at Max Planck Institute for Quantum Optics in Munich and compared via an interferometric fibre link against the laboratory Sr clock at PTB.

Our second-generation transportable Sr clock uses a single-beam trapping geometry[2] and a moving lattice[3] to interrogate the atoms. Careful characterization of the orifices in the radiation shield allowed us to accurately determine the influence of external BBR entering the shield. With this clock, we aim to demonstrate chronometric levelling at the centimetre-level, which corresponds to the resolution established geodetic methods achieve for levelling of distances of 100 km and more. Furthermore, transportable optical clocks enable comparisons of optical clocks where no optical links are available, e.g. between Japan, Europe, or America.

In this context, I will report a recent campaign, in which we brought together the transportable strontium lattice clocks of PTB and RIKEN[4] (Japan) firstly at the National Physical Laboratory (UK) and then at PTB. We compared against the local strontium lattice clock at each institute and used the fibre link connecting NPL and PTB for remote comparisons. To our knowledge, this is the first time that four optical clocks of the same type – let alone from different continents – have been compared. Therefore, this campaign is an important test of the consistency of Sr lattice clocks. We interpret the data in terms of chronometric levelling and agreement of the lattice clocks.

I acknowledge support by the Deutsche Forschungsgemeinschaft (DFG) under Germany's Excellence Strategy – EXC-2123 QuantumFrontiers – Project-ID 390837967, SFB 1464 TerraQ – Project-ID 434617780, SFB 1227 DQ-mat – Project-ID 274200144, the Max Planck–RIKEN–PTB Center for Time, Constants and Fundamental Symmetries, and the UK funded International Clock and Oscillator Networking (ICON).

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