Frequency comparisons of optical clocks and their applications

Dr. Sören Dörscher

Physikalisch-Technische Bundesanstalt
Bundesallee 100
38116 Braunschweig, Germany

Atomic frequency standards based on transitions in the optical domain are among the most accurate and precise measurement devices, reaching uncertainty down to one part in 10^{18}. These so-called optical clocks have surpassed their microwave counterparts by far. Their rapid progress holds the promise of a revised definition of the second in the International System of Units and opens new applications beyond the field of frequency metrology.

High-level comparisons are crucial not only for the validation of these clocks but also for their applications. The latter use the clocks as sensors, by measuring the frequency shifts caused by the effect under investigation. We have used comparisons of optical clocks operated in several European metrology institutes for tests of fundamental physics, to constrain temporal variations of fundamental constants, and to search for dark matter.

We have also demonstrated chronometric levelling with optical clocks in the field for the first time. This levelling technique uses clocks to directly measure geopotential differences between remote locations, by exploiting the fundamental gravitational red shift of the clocks' frequencies. A transportable optical clock has been developed in our group for this purpose. It has been used in levelling campaigns over distances of several 100 km and with measurement resolution of few 10 cm.