Development of transportable optical lattice clocks and applications

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An "optical lattice clock" benefits from a low quantum-projection noise (QPN) by simultaneously interrogating many atoms trapped in an optical lattice [1]. The essence of the scheme is an engineered perturbation based on the "magic frequency" protocol, which has been proven successful up to 10^{-18} uncertainty [2-4]. About a thousand atoms enable such clocks to achieve 10^{-18} stability in a few hours. This superb stability is especially beneficial for chronometric leveling [5-7], which determines a centimeter-level height difference of the clocks located at remote sites by the gravitational redshift [8].

In transportable clocks [9], the potential stability of the optical lattice clocks is severely limited by the Dick effect [10] caused by the frequency noise of a compact clock laser. We proposed a "longitudinal Ramsey spectroscopy" [11] to improve the clock stability by continuously interrogating the clock transition. Two key ingredients for the continuous clock, continuous loading of atoms into a moving lattice [12] and longitudinal excitation of the clock transition, are reported. In addition, we report our recent development of compact and accurate optical lattice clocks in collaboration with industry partners.

This work received support from JST-Mirai Program Grant Number JPMJMI18A1, Japan.

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