

# 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.

**Author:** Prof. KATORI, Hidetoshi (The University of Tokyo)

**Presenter:** Prof. KATORI, Hidetoshi (The University of Tokyo)

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