An enhancement cavity for controlling lattice light shifts of a ^{87}Sr clock at a 10^{-18} level

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Controlling the ac-Stark shift of the clock transition that is caused by the optical lattice is one of the most complex aspects of operating a high-performance strontium optical lattice clock. In addition to various higher-order effects, it depends sensitively on the motional state distribution of the atomic ensemble and the polarisation state of the lattice light. These challenges motivate efforts to refine our physical understanding of the relevant effects, to improve atomic state control, and to explore more favourable operating conditions.

We present our efforts to control the light shift of the clock transition frequency in the PTB-Sr3 clock at a level of 10^{-18}, reporting in particular on the installation and characterisation of an external enhancement cavity for the optical lattice. Thereby, we increase the range of accessible lattice depths, lower the required laser power, and thereby enable investigation of the effect of laser spectral purity by comparisons of the shifts caused by different laser sources. The degeneracy of the linear polarization eigenmodes is lifted by 90° reflection on a mirror inside the cavity to ensure high polarization purity. We also investigate laser frequency-to-amplitude modulation conversion by the cavity, which has been found to cause parametric heating of the lattice-trapped atoms in some cases[1]. Finally, we report on improved theoretical modelling of the light shift, based on the previous experiments[2] and discuss the plans for techniques[3] to improve state preparation.

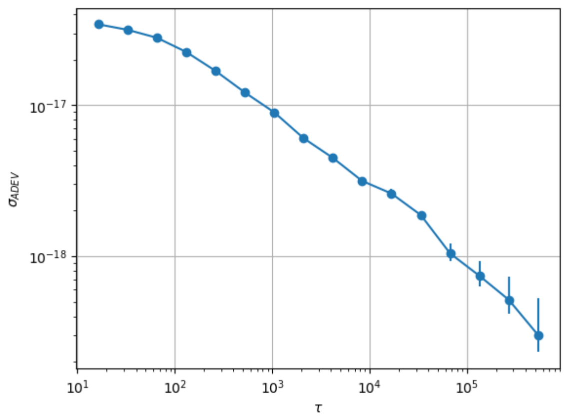

Fig. 1: Instability (total deviation) of the differential lattice light shift between two lattice depths as measured by an interleaved comparison.

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