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High-Accuracy Optical Clock Based on ^{115}In^{+} / ^{172}Yb{}ˆ+$ Mixed-Species Coulomb Crystals

Wednesday, 27 September 2023 10:00 (30 minutes)

Optical clocks based on mixed-species Coulomb crystals promise reductions of both statistical and systematic uncertainties beyond the state of the art.

We operate an optical clock based on the combination of $^{115}\mathrm{In}^{+}$ (clock) and $^{172}\mathrm{Yb}^{+}$ (auxiliary) ions, which we have identified as a candidate for multi-clock-ion operation with 10^{-19} level systematic uncertainties [1,2].

Our approach uses short linear chains (˜10 ions), in which the permutation of species is actively controlled to ensure efficient and reproducible sympathetic cooling conditions [3]. The systematic uncertainty is currently evaluated as 2.5×10^{-18} for operation with a single In^{+} clock ion, which yields an instability of $\sigma_y = 1.6 \times 10^{-15}/\sqrt{t}$ [4]. The clock has participated in local and international comparisons, and operation with up to four clock ions has been demonstrated.

Besides its use for sympathetic cooling, mixed-species operation also allows the reduction of systematic uncertainties. Fluorescence from the $^{2}\mathrm{S}_{1/2}$ to $^{2}\mathrm{P}_{1/2}$ cooling transition in Yb^{+} is used for excess micromotion compensation during clock operation. Uncertainties of the differential polarizability and the $^{3}\mathrm{P}_0$ g factor of In^{+} can be reduced using interleaved interrogation of different transitions in the mixed-species system. These measurements can reduce the frequency uncertainty contributions due to black-body radiation and the 2nd-order Zeeman shift from their respective current values close to 1×10^{-18} by more than an order of magnitude each.

[1] N. Herschbach *et al.*, Appl. Phys. B **107**, 891 (2012)
[2] J. Keller *et al.*, PRA **99**, 013405 (2019)
[3] T. Nordmann *et al.*, in preparation
[4] H. N. Hausser *et al.*, in preparation

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