

Dual wavelength high-finesse cavity for neutral mercury clock

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We report on the development and implementation of a high-finesse, dual-wavelength ultra-low expansion (ULE) cavity [1] for laser frequency stabilization in a dual-species neutral mercury optical atomic clock. The system is designed to enable high-resolution interrogation of two sub-hertz clock transitions ($1s_0 - 3p_0$ and $1s_0 - 3p_2$) with improved long-term frequency stability. The reference cavity supports two distinct optical wavelengths (1064 nm and 908 nm) relevant to neutral mercury spectroscopy, with a finesse exceeding 100,000 at both frequencies. This is achieved with engineered dielectric mirror coatings that provide high reflectivity and low optical loss across two spectral regions. Independent Pound–Drever–Hall (PDH) locking schemes [2] are implemented for each wavelength, requiring precise mode matching, polarization control, and suppression of residual amplitude modulation. The cavity is thermally stabilized near its zero-crossing temperature to minimize frequency drift, and active thermal stabilization reduces thermo-optic effects that could otherwise introduce wavelength-dependent shifts in the effective cavity length. By providing a common ultra-stable reference for both lasers, the dual-colour cavity enables narrow-linewidth [3] and low-noise probing of the two clock transitions. This approach significantly enhances spectral resolution, signal-to-noise ratio, and frequency stability, thereby improving the precision and accuracy of clock transition spectroscopy in neutral mercury system [4].

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