

A chip-scale atomic beam clock

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Atomic beams are a longstanding technology for atom-based sensors and clocks with widespread use in commercial frequency standards. Here, we report the development of a chip-scale atomic beam platform and the demonstration of a microwave atomic beam clock built on this platform [1]. The chip-scale beam device consists of a hermetically sealed vacuum package fabricated from an anodically bonded stack of Si and glass wafers with internal components for producing alkali vapor, collimating the atomic beam, and passively maintaining the vacuum environment. Rb vapor is produced in an internal cavity and atomic beams are generated using an array of etched microcapillaries [2,3]. The atomic beams propagate in a 15 mm long drift cavity, and characterization of the atomic flux and divergence indicates a collision-less background vacuum environment < 1 Pa. A microwave atomic beam clock is formed using Ramsey coherent population trapping (CPT) spectroscopy across a 10 mm distance in the drift cavity [4,5], and we have demonstrated an initial fractional frequency stability of $\approx 1.2 \times 10^{-9}/\sqrt{\tau}$ for integration times, τ , from 1 s to 250 s. Optimized operation of this clock is expected to provide frequency stability at the 10^{-12} level, and there is potential for realizing an integrated atomic beam clock in a compact and low-powered package with long-term stability exceeding that of chip-scale, buffer-gas based clocks.

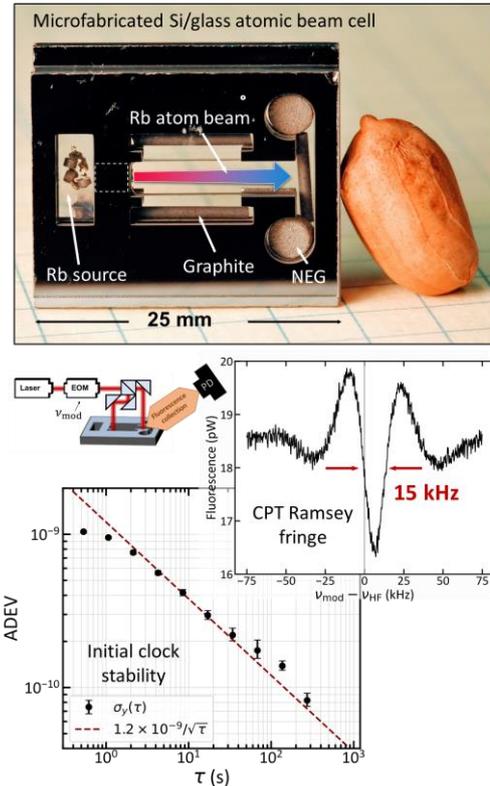


Fig. 1. Chip-scale atomic beam cell (peanut for scale), CPT Ramsey fringes, and initial microwave atomic clock stability demonstration.

References:

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