Stability of Optical Frequency References Based on Acetylene-filled Kagome-structured Hollow Core Fiber

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Abstract: A fiber laser at 1532 nm is stabilized to a sub-Doppler feature in acetylene inside hollow core kagome structured photonic crystal fiber. Short term stability is evaluated by beating against a Cr:forsterite laser-based frequency comb.

OCIS codes: (300.6460) Spectroscopy, saturation; (060.5295) Photonic crystal fibers

Acetylene offers an excellent optical frequency reference in the telecommunciations band. Hollow optical photonic crystal fibers filled with acetylene offer portability and optical intensities high enough to realize sub-Doppler features without the use of power build-up cavities. However, the small core sizes create transit-time limited linewidths of 20-40 MHz [1]. Kagome structures offer larger core sizes and therefore narrower sub-Doppler features, as shown in Fig. 1a, and exhibit less surface mode coupling than typically observed in photonic bandgap fiber [2, 3]. We have stabilized a narrow linewidth fiber laser (Orbits Lightwave) to a saturated absorption feature using an rf technique [3, 4]. Recently we have improved the signal-to-noise ratio to that shown in Fig. 1b by using polarization-maintaining optical fiber components and improved electronics. To measure the stability of the resulting locked fiber laser, we have compared the locked fiber laser to a Cr:forsterite laser-based comb referenced to a GPS-disciplined Rb clock [5]. The stability of the heterodyne beat between the comb and the stabilized fiber laser (Fig. 1c) is limited by the GPS-disciplined Rb clock at less than 1 s gate time, and is $4{\cdot}10^{-11}$ at 1 s.

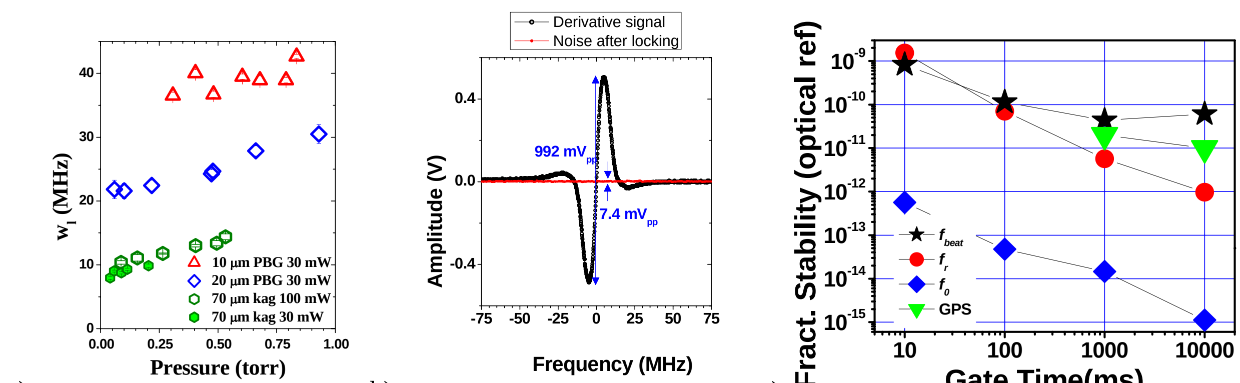

Fig. 1 (a) Lorentzian linewidth of saturated absorption features in several different fibers, including 10 µm and 20 µm photonic bandgap fiber [1] and 70 µm 19-cell kagome fiber. (b) Sub-Doppler dispersion signal obtained with rf locking technique. (c) Stability of the optical frequency comb repetition rate (f_r) and carrier-envelope offset frequency (f_0), the beat frequency (f_b) between the acetylene-stabilized fiber laser (f_x) and the comb, and the GPS disciplined Rb clock that references the frequency comb (f_{GPS}). These stabilities are Allan deviations (σ) referenced to the optical domain, so the circles represent $\sigma(f_r)/f_r$, diamonds show $\sigma(f_0)/f_x$, stars are $\sigma(f_b)/f_x$, and triangles are $\sigma(f_{GPS})/f_{GPS}$.from manufacturer specifications.

Funding was generously provided by NSF and AFOSR.

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