High-bandwidth intensity and phase noise stabilization of an Yb:fiber femtosecond frequency comb

Tobias P. Lamour[1], Dylan C. Yost[1], Theodor W. Hänsch[1,2] Thomas Udem[1]

[1]Max-Planck-Institut für Quantenoptik, Hans-Kopfermann-Strasse 1, 85748 Garching, Germany
[2]Ludwig-Maximilians-Universität München, Fakultät für Physik, Schellingstrasse 4/III, 80799 München, Germany

Email: tobias.lamour@mpq.mpg.de

We present a high-bandwidth feedback scheme, suppressing intensity and phase noise of a polarization Kerr-Lens mode-locked Yb:doped fiber laser. Intensity noise suppression is achieved with a pump diode current servo-loop while the phase is conserved through a piezo-actuated mirror. We will present in-loop measurements of the phase noise, using an optical heterodyne beating against a CW laser, demonstrating >20dB phase noise suppression over a bandwidth of 200kHz. The pump diode current servo suppresses intensity noise with >20dB and unity-gain crossing of 600kHz. Transfer functions of the laser system and the piezo actuator will be presented in detail.

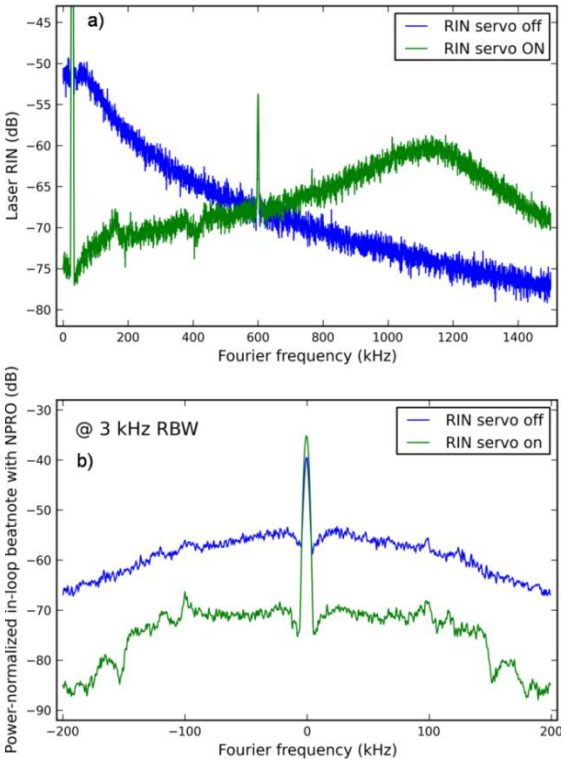

Fig. 1: a) Relative intensity noise (RIN) of the laser with pump diode servo off (blue) and on (green). b) Heterodyne beat notes with RIN servo off (blue trace) and on (green trace).

Frequency metrology has evolved as one of the main applications for frequency combs, where the repetition frequency (f_{rep}) and the carrier envelope offset frequency (f_0) must be phase locked. Coupling of frequency combs into enhancement cavities for trace molecular detection or intracavity high- harmonic generation (HHG), are more recent applications, where the coupling efficiency increases if the phase noise of the comb modes are minimized. Here, a commercial Yb-doped fiber oscillator (Menlo Systems, Orange) was used, emitting >100mW of average power, a 1035-nm center wavelength and a repetition rate of 128MHz. A dominant source of broadband phase noise in fiber oscillators are intensity fluctuations of the pump diode resulting in amplitude-to-frequency noise conversion due to the nonlinear mode-locking scheme.

The intensity noise detector, pump diode servo and phase lock were similar to the one Cingöz[1] used in his experiment. However, adjustments on the feedback electronic of both servos provided increased piezo bandwidth (>120 kHz) and decreased RIN noise level, leading to a signal-to-noise increase on the beat note signal of >15dB over more than 200 kHz. Independent setups were used to measure and optimize the transfer functions of the detectors, servos and controllers.

[1] Cingöz, A. et al. 2011. "Broadband phase noise suppression in a Yb-fiber frequency comb." *Opt. Lett.* 36(5).