Phase lock between diode lasers

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Diode lasers are widely used to address atomic transitions, e.g. in spectroscopy, quantum sensing or optical clocks. In many applications, a pair of lasers with well-defined frequency difference and constant relative phase is required. Examples include driving of Raman transitions, electromagnetically-induced transparency (EIT), photon storage and frequency combs. This is commonly achieved using phase locks [1]. They allow for a synchronization of the two oscillators with difference frequencies of several GHz. Phase locking two laser fields to each other is possible by utilizing their beat signal, typically recorded with a fast photo-detector, and fast feedback to one of the lasers. To this end, diode lasers are ideal, because they allow for very fast control of the emission frequency via the diode current.

In this contribution, we demonstrate phase locking of two external cavity diode lasers (ECDLs) as well as of two distributed feedback (DFB) lasers. We discuss the requirements on servo electronics and laser, and show a straightforward realization with commercially available components. For the phase-locked ECDLs, distinguished by their narrow intrinsic linewidth of about 50 kHz, we find more than 99 % power in the carrier. The free running linewidth of DFB laser diodes is usually larger than in ECDLs due to the shorter laser resonator, e.g. 500 kHz for the DFB lasers studied here [2,3]. Nevertheless, we still achieve good phase locking because the bandwidth of the feedback circuit, testified by servo oscillations at about 5 MHz, by far exceeds the laser linewidth. The lock is extremely robust against mechanical and acoustic noise as well as against long-term drifts, as typically induced by changes in temperature and air pressure. Under all foreseeable operation conditions, the lock will never be lost. The presented measurements prove that stable phase locking of ECDLs and DFB lasers is indeed possible and actually quite simple given the right components. The demonstrated fast feedback also proves that diode lasers are ideally suited for absolute frequency stabilization, which is at the heart of many applications employing hot atomic vapors.

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