Application Note
QUANTUM TECHNOLOGY

Max Planck Institute of Quantum Optics (MPQ), Garching

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Locking of multiple lasers to an Optical Frequency Comb

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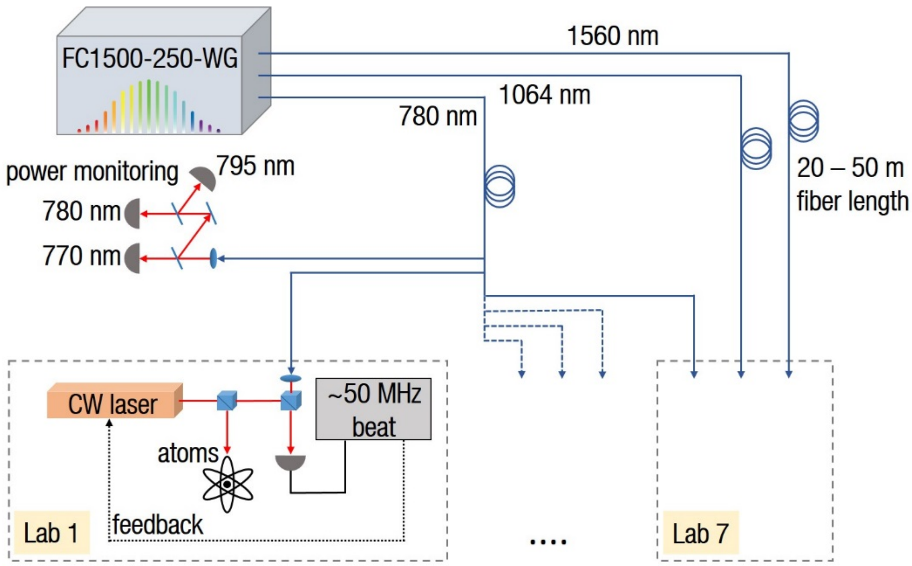
In the Quantum Dynamics group headed by Professor Gerhard Rempe at the Max Planck Institute of Quantum Optics, multiple labs are moving towards locking all lasers required for cold atom experiments to a frequency comb (FC1500-250-WG). As opposed to locking to wavemeters, gas cells, and transfer cavities, the lasers now rely on the absolute stability of the frequency comb in transferring the stability of the MPQ hydrogen maser into the optical region. This transition has developed from many years of cooperation between Menlo and MPQ.

Groundbreaking experiments performed in the group include an elementary quantum network [1] and an atom-photon quantum gate [2]. For these and many more, lasers need to be fixed at specific frequencies over days and even weeks on end.



Light from the centrally located frequency comb is distributed through fibers to seven labs in total. Depending on the exact needs, either frequency locks or phase locks are used to lock up to 22 lasers to the comb simultaneously. The most commonly used atomic species in the Quantum Dynamics group is rubidium. From the second harmonic output of the erbium frequency comb, all necessary wavelengths can be covered, ranging from 780 nm and 795 nm in rubidium to 1064 nm and 1560 for various molecules [3]. Since various sub-groups use the comb simultaneously, 24/7 operation is a must, and it is common that the comb and the laser locks run for months on end without interruption.

The second harmonic output from the frequency comb is split using fiber optic beam splitters and then distributed to the different labs through optical fibers up to 50 m in length. In each lab the comb light is split up further using free-space dichroic mirrors for lasers that are located closely to each other. Here, fast detectors are used to generate beat signals with the relevant portions of the frequency comb. For frequency locking of the lasers counters are used, and a slow feedback signal controls the laser output frequency to keep it at a specific absolute frequency. When the requirements for frequency stability and accuracy are higher, phase detectors are used and phase-locks are integrated using a variety of locking electronics, to ensure a tight lock between laser and frequency comb.

Publications:

[1] S. Ritter et al.: An elementary quantum network of single atoms in optical cavities; Nature Vol. **484**, p. 195 (2012)

[2] Reiserer et al.: A quantum gate between a flying optical photon and a single trapped atom; Nature Vol. **508**, p. 237 (2014)

[3] Prehn et al.: Fast, precise, and widely tunable frequency control of an optical parametric oscillator referenced to a frequency comb; Review of Scientific Instruments Vol. **88**, p. 033101 (2017)

Weblinks:

Quantum dynamics group:
https://www.mpq.mpg.de/4743180/quanten

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