Cooling laser stabilization on molecular iodine at 556 nm for ytterbium

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Ytterbium is a widely-used atom in cold atoms experiment, owing to its rich internal structure. In particular, it displays a 181 kHz-wide intercombination line at 556 nm on the $^1S_0 \rightarrow {}^3P_1$ transition that can be used to cool Yb atoms to the microkelvin range. The 556 nm laser can easily be frequency stabilized on commercial vapor cells: iodine presents a saturation pressure in the 0.1 mbar range at room temperature [1] and a rich and intense spectrum over the visible-NIR range [2].

Saturated absorption spectroscopy is performed on molecular iodine resolving the hyperfine structure of the P(49)24-1 transition at 556 nm. Fractional frequency stability at one second reaches the low 10^{-11} level, reported in Fig.1. A full characterization is performed on the stabilization setup using an optical frequency comb referenced by a spherical ULE cavity and an active hydrogen maser [3]. A new beatnote detection scheme, suitable for low optical powers, with a resolution up to the high 10^{-13} level is implemented using a spectrum analyzer.

The iodine P(49)24-1 hyperfine transitions are referenced with a 10 kHz accuracy performing absolute frequency measurements. Sensitivity to different experimental and environmental parameters are investigated. For example, asymmetry and misalignments are explored and characterized in the setup.

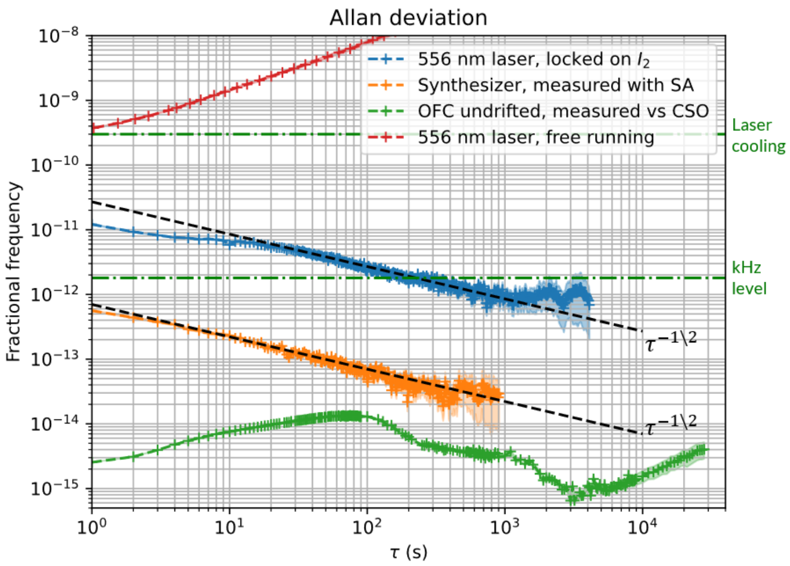

Figure 1 In blue, instability of the 556 nm laser beating with the OFC. In orange, instabilities of a low-noise synthesizer at -80 dBm measured with our scheme. In green, instabilities of the un-drifted optical frequency comb. In red free running laser performances.

[1] Dareau, PhD thesis, (2015).
[2] Gerstenkorn and Luc, I2 atlas, (1978).
[3] Didier *et al*, Appl. Opt. **54**, no 12, p. 3682 (2015).