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Atmospheric Measurement Techniques
Discussions

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Interactive comment

Interactive comment on "Laser frequency stabilization based on an universal sub-Doppler NICE-OHMS instrumentation for the potential application in atmospheric Lidar" *by* Y. Zhou et al.

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Answer to the Anonymous Referee #3

The answers to the reviewers' comments are as follows, the revised paper is added to the Supplement.

The manuscript tilted by "Laser frequency stabilization based on an universal sub-Doppler NICE-OHMS instrumentation for the potential application in atmospheric Lidar" made a frequency stabilized laser based on cavity enhanced optical heterodyne molecular spectroscopy named as NICE-OHMS.

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Discussion paper

The text line of 30 in the page 5 is as following: "The performance of the frequency stabilization were assessed by Allan plot of the frequency deviation estimated from the error signals, i.e. the sD NICE-OHMS signals, calibrated by the slopes at the zero crossing point of the sD signals."

Analysis of servo error signal is not right way to characterize the performance of frequency stabilized laser. The electronic servo box can drive the laser frequency to make error signal at the zero-crossing point of the sD signals. Fig.3 shows the baseline of sD signals (blue line) is moving around the zero-crossing point. The servo box adjusted the laser frequency to make error signal at the zero-crossing point, therefore the laser frequency is unstable. So I hope the authors to make two independent frequency stabilized lasers and make analysis of the beating signal between two lasers to characterize the performance of frequency stabilized laser.

Answer: Thanks for your suggestions on the paper. For evaluating the frequency stability of a stabilized laser, we agree that the close-loop frequency deviation as a function of time can be determined by the beat signal of two duplicate systems, however, as a alternative, it can also be determined by the calibrated close-loop error signal [1, 2]. For simplicity, our paper follows the latter method. Therefore, there are no revisions on the paper for up-mentioned comments.

The performance of stabilized laser is dependent on the length of cavity, pressure of cell, input light power to the cavity, beam size inside of the cavity, cell temperature instability, the cavity output light power and the RAM in the sD signal. So the authors need to add analysis and optimization for the parameters which affect the frequency instability of the stabilized lasers.

Answer: Thanks for the comments. For the sub Doppler NICE-OHMS signal, as you mentioned, the gas pressure, intracavity power and the beam size inside the cavity will influence the amplitude and linwidth of the sub-Doppler signal, which definitely causes different laser locking performance[3, 4]. However the aim of this paper is to show that the sub Doppler NICE-OHMS signal can be used to the frequency stabilization in the field of atmospheric LIDAR even under the not fully optimized conditions. Therefore “However the laser frequency locking performance is strongly influenced by the amplitude and linewidth of sD NICE-OHMS signal which will be changed by the gas pressure and intracavtiy power. Although the locking results in the paper have satisfied the requirements of atmospheric LIDAR applications, if the NICE-OHMS system is optimized, an even better result can be expected.” is inserted after the last paragraph of section 4.

The residual amplitude modulation (RAM) will cause the drift of baseline of the sD signal. In order to suppress the RAM, a fiber EOM with proton exchanged waveguide is used in this system since this type of EOM can filter out the polarization component along the ordinary axis. More detail can read the reference [5]. “The upturn of Allan deviation is due to the not fully suppressed residual amplitude modulation of fiber EOM, the not perfect design of PDH servo and etalon noise in the beam path.” is inserted into the last of second paragraph of section 4.

“During the measurement, the averaged temperature stability of the cavity is better than 0.5 K/hour since the cavity is exposed in the air.” is inserted to the cavity description of the paper. The variation of the cavity temperature will cause different Doppler broadening linewidth, however the sub-Doppler signal is obtained by addressing the molecules with zero velocity component along the beam direction. As a result, the temperature will not evidently influence the error signal.

When the NICE-OHMS is performed, the cavity length is locked to the laser frequency. Meanwhile, the sD signal is obtained by scanning the cavity length thereby the laser frequency. Therefore the cavity length will not influence the error signal.

A new sD NICE-OHMS system based on a f-SSM and 100000 finesse cavity is being performed in our lab. All the up-mentioned factors will be considered in our next works.

1. T. L. Chen and Y. W. Liu, "Noise-immune cavity-enhanced optical heterodyne molec-

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Discussion paper

ular spectrometry on N2O 1.283 mm transition based on a quantum-dot external-cavity diode laser," Optics Letters 40, 4352-4355 (2015).

2. H. Dinesan, E. Fasci, A. Castrillo, and L. Gianfrani, "Absolute frequency stabilization of an extended-cavity diode laser by means of noise-immune cavity-enhanced optical heterodyne molecular spectroscopy," Optics Letters 39, 2198-2201 (2014).

3. O. Axner, W. Ma, and A. Foltynowicz, "Sub-Doppler dispersion and noise-immune cavity-enhanced optical heterodyne molecular spectroscopy revised," Journal of the Optical Society of America B-Optical Physics 25, 1166-1177 (2008).

4. A. Foltynowicz, W. Ma, and O. Axner, "Characterization of fiber-laser-based sub-Doppler NICE-OHMS for quantitative trace gas detection," Opt. Express. 16, 14689-14702 (2008).

5. I. Silander, P. Ehlers, J. Wang, and O. Axner, "Frequency modulation background signals from fiber-based electro optic modulators are caused by crosstalk," Journal of the Optical Society of America B-Optical Physics 29, 916-923 (2012).

Please also note the supplement to this comment:
https://www.atmos-meas-tech-discuss.net/amt-2018-389/amt-2018-389-AC3-supplement.pdf

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