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Atmospheric Measurement Techniques Discussions

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.

Anonymous Referee #2

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General comments:

This paper develops a NICE-OHMS-based laser stabilisation system for potential application for lidar. The authors provide a brief overview of the relevant technical aspects of the paper, including sub-Doppler spectroscopy, the NICE-OHMS technique and the laser technology used in various NICE-OHMS demonstrations. The highlight of the paper is the application and use of a fiber-coupled optical single-sideband electo-optic modulator (f-SSM) to make the system useful for laser stabilisation to a variety of lasers, and they demonstrated this by stabilising both an Erbium-doped fiber laser (EDFL) and a whispering gallery mode (WGM) laser. After producing a sD NICE-

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OHMS signal with each laser (using acetylene as a reference gas), each laser was then stabilised to that acetylene transition frequency using the sD NICE-OHMS signal produced. The stability of the stabilised output was measured and found to exceed the level needed for use in lidar systems.

The paper is well organised and clearly written, for the most part. Although the applicability of this system to lidar needs to be expanded upon, I see no reason why it could not be used as a stabilised seed laser for lidar.

Specific comments:

What was the acetylene gas source for your initial experimental realisation of this, and how did you measure that it was at 100mTorr? Do you know the long-term stability of the pressure in the system? Would you expect to use the same system setup “in the field” when supporting a lidar system?

Can you be more explicit about the stability requirements of a lidar system? What about the power required to stabilise such a system, can you give the details of the power requirement and can your system provide that power?

Lidar systems also would like to target other molecules, especially those related to greenhouse gas emissions (CO2, methane, etc.) Can you comment on how adaptable your system is to these other molecular species?

Can you provide any comments at the end of your paper to indicate what changes would need to be made to your system for it to work reliably outside a research laboratory, “in the field”?

Page 3: Line 1: I am confused by this first sentence. The “noise immunity” obviously refers to “noise” sources - not the actual signal. The “background signal” you mention is induced by other processes unrelated to the “noise” in the “noise immunity” - from optical power variations in the incident light to the cavity, or coupling efficiency. Can you please clarify or remove this sentence?

Page 6: Line 6: “for integration times up to 240 sec” - I might argue that you have over-estimated your white noise response window, especially in the case of the fiber laser Allan deviation data (black points and curve). I would estimate (reading directly off Figure 4) that there is a white noise response out to 100-120 seconds (the intersection of your “white noise” line and a flat line indicating the ADEV value when the ADEV begins drifting up), rather than 240 seconds, for the fiber laser. By 240 seconds you are clearly out of the white noise regime. However, it is a bit difficult to see this clearly from the graph. Additionally, it is not obvious that there are any “dotted” lines on this plot, as mentioned in the figure caption - the “white noise response” lines appear solid.

Figure 4: To be able to better compare the signal-to-noise-ratio of the sD NICE-OHMS signals in sub-plots (a) and (b), it would be helpful to have the y-axes have the same minimum and maximum values (perhaps 0.7 or 0.65).

Technical corrections: Page 1: Line 1: Typically one would use “a universal” rather than “an universal”. Line 26: “a relative weak” -> a relatively weak

Page 2: Line 22: “cavity with a finesse of 105” - > “cavity with a finesse of 100,000” or “cavity with a finesse of 10ˆ5” Line 24: should be rewritten - “sensitivity of 1x10ˆ-14 cm-1 at 1-s averaging time.”

Page 3: Line 6/7: “more than one frequency actuators are usually utilized often a” -> “more than one frequency actuator is usually utilized, often a”

Page 5: Line 30: “The performance of the this frequency stabilization were assessed by” -> “The performance of the this frequency stabilization were was assessed by”

Page 6: Line 15: “testified” - > “tested”

Generally there is sometimes an issue of spacing between text and the beginning or end of parentheses that should be checked for throughout the paper.

It is a bit confusing to have two very similar References (Ehlers, 2014) and (Ehlers et al., 2014) in the paper text, there a way to differentiate? (Ehlers [Thesis], 2014)? Also,

I am not sure that the page 7, line 24 Ehlers reference, is correct. Perhaps use “PhD dissertation” rather than “Doctor”. “Ehlers, P.: Further development of NICE-OHMS – an ultra-sensitive frequency-modulated cavity-enhanced laser-based spectroscopic technique for detection of molecules in gas phase, PhD dissertation, Umeå universitet, Umeå, 2014.”

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