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Review of the article

“Simultaneous Temperature and Wind Profiling in the Troposphere and Lower Stratosphere Using a Rayleigh Doppler Lidar with a Fizeau-Interferometer-Based High-Spectral-Resolution Receiver“

submitted by Pu et al.

(AMT)

Review Summary

The paper manuscript “Simultaneous Temperature and Wind Profiling in the Troposphere and Lower Stratosphere Using a Rayleigh Doppler Lidar with a Fizeau-Interferometer-Based High-Spectral-Resolution Receiver” by Pu et al. presents a novel lidar system based on an imaging Fizeau interferometer and a multi-channel PMT array that is used to resolve the Rayleigh-Brillouin spectrum for measuring temperature and wind profiles. Although the underlying technology is not new, this is the first time that it has been used to measure both temperature and wind simultaneously and up to 20 km, which is indeed very interesting for atmospheric science applications. The paper is clearly written and well structured. Regarding the scientific presentation, however, I have identified a few major issues, as discussed below. In my opinion, it is important to address these points accordingly before the paper can be considered for publication in AMT.

Comments:

- **Line 16:** “To overcome these limitations”… I think especially the sensitivity to Mie scattering is not solved yet. Your temperature profiles can only be used above 5.3 km due to the contamination from aerosols. Hence, I would skip this argument in the abstract.
- **Line 64:** As you are addressing RB scattering research, which I think is indeed very crucial for the presented measurement technology, it might be useful to mention the first studies performed in air: https://doi.org/10.1364/AO.49.004217
- **Line 137:** You approximate the Fizeau transmission function, which is only a valid approach for low-Finesse systems. For high-Finesse Fizeau interferometers, a clearly asymmetric transmission function arises, which has to be considered. I would recommend justifying your approach here.
- **Line 155:** In the Rayleigh-Brillouin community, your parameters “a” and “b” are usually called the dimensionless frequency “x” and the parameter “y.” I think you could either use this nomenclature or, at least, briefly mention it here.
- **Line 159:** I think it is better to call θ the scattering angle. It would also be useful to give numbers for the shear viscosity in air (the value that you use) and for $\theta = 180°$ for lidar measurements.
- **Line 164:** It is very important to distinguish between the correct physical line-shape model by Tenti, which has no closed analytical form, and the approximation by Witschas, which is based on the superposition of three Gaussians, as you show in Eq. (8). As Witschas derived his model based on the x and y parameters, it is indeed possible to substitute these and make it dependent on p and T. However, it has to be made clear that this is the equation by Witschas and not the Tenti model.
- **Line 175:** Can you also provide numbers for the spectral pulse width as well as the frequency stability of the laser, which are both important quantities for the applied technology?
- **Line 180:** Using a multimode fiber should cause speckle issues in the imaged fringes. How do you deal with that? Do you use an additional fiber scrambler? Further, the larger fiber core

together with the NA of 0.22 broadens the transmission fringe of the Fizeau significantly (compared to SM fiber illumination). Do you consider that? Does this cause error sources?

- **Line 192:** Why do you not use the transmission formula of a Fizeau interferometer, as for instance introduced by Born and Wolf?
- **Line 197:** Have you performed any further numerical simulations to optimize the specifications of the applied Fizeau interferometer? Or is this a justification that you can use an existing Fizeau interferometer for your test measurements (which would be fine, of course)?
- **Line 200: Table 2:** I would expect further important specifications of the Fizeau interferometer to be mentioned here. Especially the mean plate reflectivity as well as the wedge angle that was used.
- **Line 204: Simulation-based parameter optimization:** I do not fully understand the approach or the outcome of this simulation. There is a pretty good estimation of the accuracy for the center and width determination of a Gaussian considering Poisson and white noise (Hagen et al., 2007, https://doi.org/10.1364/AO.46.005374). In this study, it is explained that one needs a certain number of channels (~3) to reach a certain accuracy. When increasing the number of channels, the accuracy does not improve, as the result of each channel gets less accurate (square root of the photons in each channel). Hence, I would expect that you do not see big differences between 32 channels and 64 or 128 channels. Of course, this also depends on the actual fringe shape that you are using, as well as on the conversion factor (channel width and corresponding imaging). I would either suggest clarifying (and checking) these points or maybe skipping this section for this paper, as it is not of primary importance.
- **Line 275:** I do not understand what is shown here. Do you say that, when analyzing a simulated RB spectrum, your algorithm converges after about one iteration? This makes no sense to me. But maybe I do not understand this figure correctly.
- **Line 285:** It could be helpful to show a few exemplary RB spectra showing how they are used in this simulation, to get a better feeling for what you are analyzing. I would suggest showing both the spectra as well as the best fit, and the corresponding T, p, and Mie that were used for the simulation and retrieved from the fit. With that, the results shown in Fig. 6 could also be much better interpreted.
- **Line 297: Calibration:** For the transmission curve measurement that you show here, it is not clear if you use the same fiber (200 µm, NA = 0.22) that you also use for atmospheric measurements. Furthermore, the fiber illustrates that your imaging setup is defined such that you do not measure down to the “valley” of the transmission curve. This is even less true when the spectrum is convolved with the RB spectrum. This is something I do not understand. Although the edges of the spectrum do not contain many photons, the determination of the valley is important to determine the FWHM of the measured spectrum and hence the temperature. Why do you choose such an imaging configuration? Have you performed simulations that would justify this approach?

  Further, one point that is not discussed in the paper but that is very important is how you transfer the pixel position to a real frequency. Do you have a scannable laser for doing so? How stable is this over time?

  Last but not least, the accuracy of the suggested technique significantly depends on a proper correction of the illumination function. How do you perform this correction? How stable is the illumination function over time?
- **Line 315, Fig. 8:** This figure actually illustrates the point I mentioned above. The measured raw signal does not reach the valleys. Furthermore, the shown spectrum is pretty asymmetric. I do not understand how you can retrieve such precise temperature and wind values from this raw signal. Could you clarify that? Could you show the best fit to these particular spectra and the fit values that you retrieve? Is the blue curve the best fit to the

purple data points? If so, I think there must be something wrong. With such poor agreement, it should be impossible to derive correct parameters. But maybe I do not understand this correctly here.

- **Line 344, Fig. 10:** I do understand that the temperature retrieval is significantly impacted by Mie scattering, but the wind retrieval shouldn't be. As it is "just" a determination of the fringe position, this should also work in the vicinity of Mie scattering. Actually, it should even provide better results due to the higher signal levels. Could you clarify that? The wind profiles start already at 2 km but do not go down to the ground. Is this related to overlap issues?

  Can you show further spectra for cloud returns and from the free atmosphere for comparison? Also, could you show the best-fit result? It is also not clear how you retrieve the wind. What is your reference?