B. Witschas 08.02.2025

The valuable comments given by Referee #2 (received on 27 January 2025, shown in black) are highly appreciated. The corresponding answers of the authors are given below in blue color, changes in the manuscript are highlighted in green color.

Interactive comment on "Spectral performance analysis of the Fizeau interferometer onboard ESA's Aeolus wind lidar satellite" by M. Vaughan et al. (Author response)

Referee #2

This is an excellent paper. I found it a pleasure to read and review. It describes a detailed analysis of the Fizeau interferometer used to estimate Mie-scattered winds as part of the Aeolus mission. The paper is well-organized, describing the Aeolus mission and the role of the Fizeau interferometer, the interferometer itself, and then logically proceeding to characterization of the interferometer on the ground and a summary of the performance of the component during the mission. It concludes with a very credible hypothesis for the observed reduced performance observed on-orbit, and describes improvements that could be incorporated into the interferometer design for a follow-on mission that could significantly improve performance.

The paper is both informative and tutorial. I guess I was a bit surprised that a Fizeau interferometer has not previously been analyzed using a wave-optics approach, but the utility of the approach for this analysis is certainly justified and appropriate.

In my opinion, this paper could be published without revision. If the paper is returned to the authors, a couple of descriptions in the text could benefit from a bit more explanation.

Thanks a lot for performing the review of our paper manuscript and for suggesting this work to being published in AMT. It is great that both the informative but also the tutorial character of the paper manuscript is acknowledged, as it was not trivial to find a balance between both while writing. Thank you. We will answer to each of your comments below (blue color). The corresponding changes in the manuscript are highlighted in green color.

- Line 546: The sentence beginning with "The simulation analysis…" notes that the frequency estimation algorithm was modified. A bit more discussion here on the frequency estimation algorithm would be informative.
  It seems that this phrase was misleading, as the only modification was the addition of the background as a free fit parameter. However, we recognize that we did not explain the fitting routines in sufficient detail. Therefore, we have added the following sentences to Section 5.1.2, where the fitting is first used (following line 525):
  For the analysis of the simulated fringes, a non-linear square fit of Eq. (2) was applied, using the center position x_0, the FWHM Γ_L and the area under the peak I_L as free fit parameters.
  In addition, in section 5.1.3., we add the following side note (following line 547):
  … was modified to account for a background pedestal of unknown height, adding and offset term to Eq. (2) as a free fit parameter.

- Line 640: Although the values for r and fab agree with those of specified in the previous section, it isn't clear to me how they were determined. Were these determined through simulations?
  We agree that both the explanation of the Aeolus parameter used and the derivation of r and fab were not provided in sufficient detail. This was partly due to the need to shorten the manuscript to address length constraints. To ensure the necessary information is included, we have added the

following paragraph at line 635: Considering the earlier discussions in Sect. 3 and Sect. 4, as well as an examination of the Aeolus Fizeau Mie profiles, it is considered that (before detection) these profiles are close to a Voigt profile with a FWHM of approximately 175 MHz. This profile is further described as consisting of an instrumental Lorentzian component of ~95 MHz, as retrieved from the simulations shown in Fig. 8 b, and a Gaussian component of ~117 MHz, the latter resulting from the combination of 108 MHz (instrumental AOI aperture broadening) and 45 MHz (laser pulse width). Notably, when this Voigt profile is convolved with the detector's 'top-hat' function of 100 MHz pixel width, the resulting prototype fringe has an FWHM of 205 MHz, which is very close to the one shown in Fig. 2b. From these values, the Lorentzian fraction is estimated as L = 95/175 ≈ 0.54, with a corresponding $C_v \approx 0.66$, resulting from numerical simulations similar to the one shown in Fig. 14. Using these values and following Eq. (13), extensive simulations of the SNR versus r reveal a weak, broad peak (not shown) which results in an optimal analytic bandwidth of 300 MHz. The derivation of these parameters is furthermore illustrated in the figure shown below which is not included to the manuscript to address length constraints. The left panel shows modeled Voigt profiles (FWHM = 175 MHz, $L_{fraction}$ = 0.54). The colored area indicates the area included by respective analytic bandwidths, in particular f_{AB} = 175 MHz (top), f_{AB} = 245 MHz (middle) and f_{AB} = 455 MHz (bottom). The right panel shows the evolution of k_r depending on $L_{fraction}$ for different f_{AB}/r ratios (left y-axis). The black line indicates the respective C_{CR}-value (right y-axis). The values resulting for the Aeolus parameters is depicted by the orange dashed line. This is just to illustrate that detailed numerical simulations have been performed to end up with the values given in the manuscript.