Response to comments from Referee 1

Black: Referee's comments; Blue: Authors' answers

We thank referee #1 for the review and for providing useful feedback.

Referee:

General Comments.

Good paper.

Thank you very much!

Channel fringes are probably a major source of station-to-station bias within the NDACCIRWG network, especially for weakly-absorbing gases. This is because the amplitude and phase of channel fringes can vary considerably from site to site, even for nominally-identical instruments. So the fringes must either be suppressed, or somehow accounted for in the spectral analysis, or both.

The main deficiency of this manuscript is that the authors provide no explanation of why increasing the wedge angle of the air-gap reduces the amplitude of channel fringes. The central conclusion of the paper is that an 0.8 deg angle for the air-wedge substantially reduces the channeling, as compared with the standard 0.5 deg. But the authors don't tell us why. Ideally, there would be an equation that relates the channel fringe amplitude to the relevant physical properties (reflectivity, flatness, wavenumber, wedge angle). This equation would also explain why the channel fringe amplitudes are so much larger in HgCd than in InSb. Alternatively, there should be a figure (fringe amplitude versus wedge angle for different wavenumbers) showing the results of computer modelling of the channeling.

Section 2 on the background of the Fabry-Perot effect has been largely extended. Three examples are described in detail: a plane-parallel window at normal and 30° incidence and a wedged plate. Finally, the channeling amplitude as function of wedge angle was calculated and presented in an additional Figure (Fig. 2). These examples illustrate the wavelength dependence as well as the effect of wedging. While the channeling in a plane-parallel plate is not, the reduction by wedging the optical element is wavelength dependent.

In line 95 the authors further state (correctly) that a large tilt suppresses channel fringes, but don't offer any explanation why.

An explanation is added: Wedged optical components avoid channeling because the reflected beams do not superimpose and thus, do not interfere with each other.

Wouldn't anti-reflection coating of the BS and Compensator also decrease the channeling? Explain why this isn't a feasible option?

You're right, in principle an anti-reflection coating on the BS would decrease the channeling. However, such an AR coating is hardly compatible with the broad-band concept of beam splitters used in FTIR spectroscopy. Since the BS is specified for a very large spectral range, for example from 700 to 5000 cm^{-1} for the KBr, such an AR coating would be very complex and would consist of several layers. It is very hard to completely suppress reflections for the entire spectral range without adding any undesirable effects like absorptions or reflections within this muliti-layer coating.

Finally, the authors should discuss potential disadvantages of the larger wedge. For example, might an increased wedge angle between the BS and Compensator cause alignment problems for instruments that are aligned at 1 atm and then operated under vacuum? Or is the air-gap sealed such that the air pressure between the BS and Compensator never changes? Or is there another reason why this doesn't matter?

The air gap is not sealed. In fact, there is a tiny difference in alignment under vacuum. However, this little difference occurs in instruments with small as well as with large BS wedge. So, at least part of this difference has another reason.

The disadvantage of the larger wedge is its incompatibility with other beam splitters. Of course, it is not compatible with pellicle BS used in the FIR spectral domain. Besides this, switching from small to large wedge is quite an effort since two new beam splitters are needed. The KBr BS does not transmit visible light and therefore a second BS (normally CaF_2 or glass) is needed for the alignment procedure by which interference fringes are checked by eye or camera. Furthermore, a full alignment of the spectrometer is needed when switching from small to large wedge. The alignment procedure recommended in NDACC is an effort and described in http://www.acom.ucar.edu/irwg/Griffith_alignment.pptx and https://www.acom.ucar.edu/irwg/HaseBlumenstockAlignment.pdf.

For new instruments switching to a larger wedge is easier since the spectrometer is aligned by the manufacturer. However, a BS with large wedge is not listed in the price list and is available on request only. And the company asks for orders of several items at the same time. At least for new customers or customers from outside the NDACC community this might be hard to know and to order correctly.

Once switched to a pair of beam splitters with increased and matched wedge there is no disadvantage. Of course, the spectrometer needs re-alignment when switching to a larger wedge. This has been done at several sites (Altzomoni, Izaña, Karlsruhe and Kiruna) and is working fine. Switching within this new pair of beam splitters is possible without realignment. The ILS of these instruments is good.

The disadvantages of the larger wedge are discussed in lines 233ff. A few sentences were added here.

Paper should be publishable once these issues (above) are addressed. The authors should also address the more technical problems discussed below.

Specific Comments.

Line 40: "0.9 and 0.11 or 0.23" is ambiguous. I suggest two sentences, one describing air gap periods, and the second discussing the substrate periods.

Done.

Line 45: quantify "significantly"

A sentence is added to quantify the reduction of channeling amplitude with increasing wedge of the air gap.

Line 62: Here you use % as the unit of channel fringe amplitude. Is this a typo? In other places you use ‰. Choose a unit and be consistent.

Done. It was not a typo. We thought % is more appropriate in the introduction to give the magnitude of the effect while ‰ is more appropriate to give the exact numbers in the result section. Anyway, ‰ is used consistently throughout the paper.

Line 98: "design" à "build". It is easy to design an FTS free from channeling; just specify everything to be wedged.

Changed. Well, some devices are difficult to wedge, for example pellicle beam splitters or detector elements. The latter might also cause channeling. Finally, it depends on the wavelength as pointed out in chapter 2. In the NIR spectral domain you're right. In the FIR or even millimeter wave region, however, channel free instruments might be even hard to design.

Line 117: Explain why NDACC uses a set of filters (improve SNR and avoid saturation). This won't be apparent to a non-NDACC reader.

Done.

Line 117: here you use "arc-min" as the wedge angle unit, whereas previously you used degrees. Choose one and use consistently. Or explain why wedge angle requires two different units.

Units were taken from the data sheet of the manufacturer. Changed to degrees.

Line 121: I think that a table would be useful here (or a link to a table) that shows the spectral coverage of each NDACC filter. Also, add a column to Table 2 showing which filters were used at each site.

Done: A column is added to Table 2 and a table of the NDACC filters is added in Appendix A.

Line 130: "…spectral resolution of 0.05 cm^{-1}" is ambiguous. Add the OPD parenthetically.

Done.

Line 148: Figure 2 caption inadequate.

Modified.

Line 170: Move fig.3 earlier, before discussion of fig.4 begins.

Done.

Line 175: I don't think that the colors add much value to fig.3 since you've already told us the correspondence between the three optical cavities and their fringe periods. Perhaps add the HgCd information to fig. 3 and then use colors to denote the detector or the wavenumber of the fitted window.

Done.

Line 185: What about the fringes from the BS substrate? Are these never the largest?

You're right, there is one case: At Rikubetsu, the substrate of the KBr beam splitter causes the largest channeling amplitude. Fig. 5 has been changed accordingly. For the CaF_2 beam splitter there is no such case (line 185, Fig. 4).

Line 188: Site labels should be identical between figs.4 & 5 (IZ-18 vs IZ-2018)

Done.

Line 197: "The amplitude is even larger as compared to the InSb domain" à "The HgCd amplitudes are larger than those in the InSb domain". Explain why amplitude is larger in HdCd than in InSb domain?

Done. Is explained in Sect. 2. See also comment and additions to chapter 2.

Lines 200-203: Here you discuss the InSb domain in section 4.2 (HgCdTe Domain). Shouldn't these sentences be in section 4.1?

Fig. 6 as well as lines 200-203 present and discuss results of the HgCdTe domain. In line 200 (all line numbers refer to original version) 'HgCdTe spectra' was added for clarity.

Line 204: Figure 6 doesn't explain what the three curves are. Are these spectra from different instruments? If so, which ones? Labelling the curves as weak/medium/strong isn't helpful. I can already see with my eyes which one has the strong fringes.

The spectra are taken from different instruments. Labelling of the curves is changed.

The idea of this figure was just to visualize the range of channeling amplitudes within the NDACC network.

Line 208: Mixed units for wedge angles.

Done.

Line 211: "…with far-infrared pellicle…" à"…with unwedged far-infrared pellicle…"

Done.

Line 216: Fig.7 caption. What is the difference between upper and lower panels? Different instruments?

If so, which ones? Are the left panels from the same instrument as the right panels? In the lower left panel increasing the wedge from 0.5 to 0.8 deg. caused a factor 3 reduction in the channel fringe amp. But in the lower-right panel, the reduction was much less, perhaps only a factor 1.5. Please discuss.

These measurements were all made with the same instrument. All measurements of Fig. 7 (Fig. 8 in the revised version) were made at Bruker company in Ettlingen. In the first setup, beam splitter with 0.5°, 1.2° and 2.2° were tested (upper panel). The beam splitter was the same for all 3 angles, just different spacers were used.

Since a wedge of 0.8° was chosen for standard beam splitters a test with 0.5° and 0.8° wedge was conducted later on (lower panel). This setup used the same spectrometer as compared to the previous setup (upper panel). The beam splitter is the same for the right and left panel.

Spectra shown in the right and left hand panel show different spectral regions. The channeling amplitudes as well as the reduction factor varies presumably due to wavelength dependent reflectivity of the beam splitter.

Line 218: "To avoid the need for strongly wedged substrates…". This is confusing since the surrounding discussion is about the air-gap fringes. A strongly wedged substrate won't change the air-gap wedge, unless there is an unspoken linkage between the two.

Yes, the strongly wedged substrate won't change the air gap. The idea of line 218 is to make clear that the following paragraph is on air gap fringes only. The discussion before line 218 (line 206-212) is on a special BS with larger wedge of the substrate and of the air gap.

Line 232-233: As in line 218, here you mix the air-gap fringes and the substrate fringes. In my mind these are separate things, with different periods, controlled by different factors. So why would "a larger wedge of the beam slitter substrate" help reduce the air-gap channel fringes?

We agree that a larger wedge of the substrate does not reduce the air gap channel fringes. However, some spectrometer do also show channeling of the substrate. And therefore, in a much earlier attempt to reduce channeling, the air gap and the substrate were strongly wedged at some sites (line 206-212). This chapter is on reducing the channeling of the entire beam splitter not only of the air gap channel. Line 232f is a kind of a summary of chapter 5 highlighting the result of this study that it is possible to manufacture a beam splitter free of 0.11, 0.23 and 0.9 cm^{-1} channel fringes even with a small wedge of the substrate.

Line 234: Perhaps change "incompatibility" to "non-interchangeability"

Done.

Line 248: "Finally, we found that most spectrometers show two dominant channeling frequencies with about 0.1 or 0.2 cm^{-1} and 0.9 cm^{-1} corresponding to beam splitter substrate and beam splitter air gap. In most cases, the channeling caused by the gap of the beam splitter is the leading one. " à "Finally, we found that most spectrometers show two dominant channeling frequencies with about 0.1 or 0.2 cm^{-1} and 0.9 cm^{-1} corresponding to beam splitter substrate and beam splitter air gap, respectively, the latter usually dominant."

Done. Thank you for the corrections!