Chapter 4

Comments and questions

Comments by Sheon

*** ''reviewer'' questions**

\- ''expert'' questions

my answers:

are these my final answers? NO !!!

All comments, suggestions and also criticisms are welcome! ☺☺☺

[1] Section 1.1

*** Why is are the dimensions of the cavity as such (ROCs, length)?**

The choice of both these parameters are such that our cavity is stable. I have to add the analysis for the **cavity stability** that give me the range of the suitable values for the air gap between the crystal and the outcoupler mirror.

The RoCs must coincide with the radius of curvature of the gaussian beam inside the cavity, in correspondence of the mirrors positions.

In general, I think, 25 mm is a standard RoC for commercial mirror, and 8 mm for the curved face of the crystal is chosen to satisfy these conditions, compatibly with the transverse dimensions of the crystal.

*** Why is IR Finesse important?**

Because the OPO must resonate at the frequency of the produced squeezed beam; such that it is possible to have a higher "squeezed power" inside the cavity.

*** Why isn't green finesse important?**

Only because we chose a singly resonant cavity. With this locking configuration we need higher pump power with respect to that for a doubly resonant one.

*** What's P/Pth? Why is x = 0.8 the best and not x = 0.5?**

P/Pth is the ratio between the pump power and the threshold pump power.
This ratio must be less than 1 (sub-threshold regime) to have squeezed vacuum.
In the a previous version of the document I demonstrated that x=0.5 is the minimum value for x, in absence of losses (see attached document [pag.6, final part])

and that x=0.8 is compatible with reasonable values of the losses.
Can you verify if my analysis is correct? if so, I can re-add it in the chapter, maybe in a more synthetic way. Bachor says that x=0.8 is the maximum recommended value.

What happens if the pump power value is too near the threshold?

1.6.1 Ideal case

How said before, the amount of squeezing produced by the OPO depends on the threshold pump power. Considering an ideal case, ($\eta_{tot} = 1$ and $L = 0$) we can obtain an estimation of the lower limit value of the pump power with respect to the threshold power. As we can see in the figure (1.5), to reach 10 dB of squeezing the normalized pump power x must be at least 0.5. Then

$$P = P_{th}/4 \tag{1.4}$$

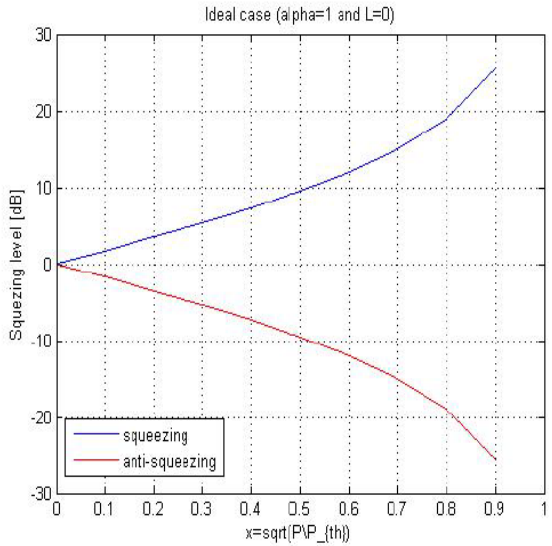

Figure 1.5. To reach 10 dB of squeezing the normalized pump power x must be at least 0.5

1.6.3 Realistic case

In a realist case ($\eta_{prop} = 0.97$, $\eta_{q.e} = 0.94$, $\eta_{hom} = 0.98$)

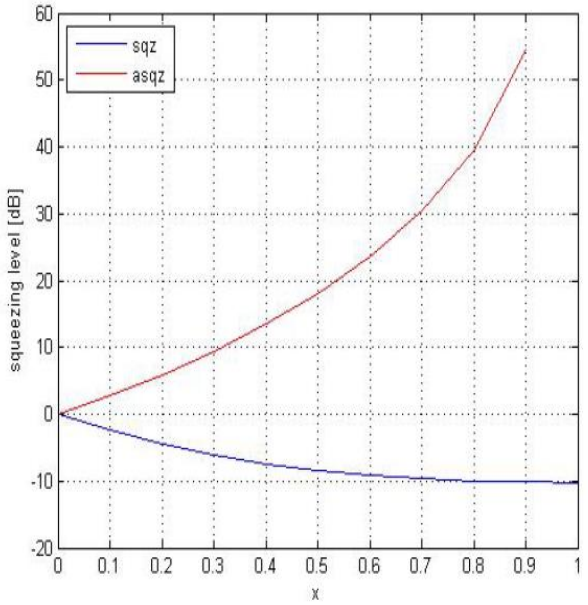

Figure 1.8. In a realistic case, considering the maximum estimated value for the intra-cavity losses, the maximum achievable level of squeezing is equal to 10 dB, that correspond to our goal.

To more questions… I change the slides-style… pardon!

> * 10 dB is the maximum? Why not more?

It is the maximum, compatibly with our losses.

> * Why 33um and 23 um as the two waist sizes?

These are the results of the calculations made using the cavity parameters; but, maybe, I didn' understand your question...

> [2] Section 1.2
> Threshold power of 14.7 mW is too low. The GEO squeezer has threshold power around 60 mW. Please double check.

I know! 14.7 mW is a wrong value (also using the formula that I wrote...).
I found the expression of the Enl parameter solving the coupled-wave-equations for the OPO. I think it is correct... but, if also the formula (1.1) is correct, the threshold pump power is really to low...
If you have the solution to this problem, or any suggestion, please help me to solve this point!

> [3] Section 1.3
> * Why is 10 dB maximum?

see above

> * You have included measurement efficiencies - what about Squeezing Ellipse Phase Noise?

I want study better this point; and add it in a next version of the chapter.

> - Is L = 0.0025 single pass loss or total intra-cavity loss?

single pass loss... But I'm not sure of this result... what are the losses that I must take into account?

I considered the residual transmittivity of the HR crystal face, the losses of the AR face and the crystal absorbtion...

> [4] Section 1.4
> Questions have been raised on the histograms at the telecon. Pairing up with the information in Chapter 3 may consolidate this. However, when presenting histogram data, all other parameters of the histogram must be presented too e.g. sampling frequency, total number of points, histogram bin widths etc.

OK!

> [5] Section 1.5
> * Why is the beam height 61 mm?

this is the height of the Mephisto S200 laser that I want to use to lock the cavity.

> - Figure 1.4 drawing on the right - the dimensions look odd to me. CAD drawings are normally to scale, and the 70 mm appears shorter than the 61 mm.

I agree! I must correct this number

> [6] Section 1.6
> Generally speaking for a multi-author document, try and avoid putting in acronyms in early drafts (unless the section is self-contained and not going to influence other sections). This prevents consistency issues later. Once the formal bench diagram is finalised with agreed-upon acronyms, then they can be added to the TDR throughout.

I agree!

Thank you, Sheon!

Questions by Jean-Pierre

Why a plano-concave outcoupler mirror? And not a meniscus?

I think that it is not necessary to use a meniscus. With a good mode-matching also a plano-concave mirror is OK

What is the meaning of this paragraph?

In order to avoid the spatial overlap between the squeezing cavity eigenmode and the input green light, matching lenses are used (see section ??). This because the interaction of the pump beam with the higher mode of the infrared light represents an additional noise and then a squeezing level degradation source. Once the cavity and the homodyne are aligned, the BAB must be switched off.

If this interaction occurs we can have the squeezing of IR higher modes and then noise for the Squeezed TEM00 mode

Comments by Matteo

"melius est abundare quam deficere"

Few questions...
section 1.1
1) Is there any optical simulation that lead you to choose the roc of the 2 mirrors of the cavity?
2) why is the IR finesse so crucial?
3) figure 1.1: what is x and why is 0.8 a suitable number? What changes if i set x at 0.9 - 0.95 - 0.99 and so on?
4) why R_532nm = 20%?
5) why PPKTP and not Lithium Niobate or KTP?
6) why 22.5mm of airgap (similar to question 1)?
7) rephrase of question 1): table 1.2 report some numbers, is there any optical simulation that lead you to that results?

Is 23micron of IR waist size an optimization of some parameters?

section 1.2
1) seems strange to me that the threshold is so low compared to the GEO600 people, but i'm not expert on this calculation.

section 1.3
1) what is L (loss per round trip or something else)?
2) again, why x = 0.8?
3) why are you not taking into account the angular jitter of the squeezing ellipse?

section 1.4
1) can you demonstrate that using a wheatstone bridge to measure the NTC is less noise than a 4W measurement?
2) why NTC-semi833 and why cp1.4.17-045? any specification about these 2 items is required.
3) why are you measuring the 2 NTC with 2 different method? what are the sensitivities of the multimeter and the other "method"?
4) note: it's ugly see an X axis in °C and a sigma in mK.
5) some info are missing into fig 1.3: sample rate, number of points, digits of precision, quantization error, ecc...

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6) the sigma of the in and out of loop ntc is pointless if you don't show the temperature stabilization of the room

(e.g. you can be in a room with a T stabilization of microK and with this

data that you are showing you are ruining the Tstabilization.
7) can you show some numbers about the PID loop? for example a cut frequency, a PSD, something...

section 1.5
1) fig 1.4: 70mm seems to be shorter than 61mm
2) fig 1.4 (left): it's not clear how the wires of the pzt or of the NTC exit the black peek.
3) fig 1.4: it's not clear how you align the input mirror or if you thought of some devices to align it.
4) fig 1.5: do you place the NTC in situ before putting the copper piece into the black peek or after? in either case, it's not trivial to understand how do you manage the wires of the NTC

section 1.6
1) what does you mean with the first sentence of the second paragraph of this section?
2) suggestion: decide the acronym with all the main writer and at a latter stage so no misunderstanding arises within the TDR document.
3) Set up already the brand of the auxiliary laser it's not "fair", describe the property of it instead.
4) maybe an image will simplify this section because actually is confusing.

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When you are solving a problem, don't worry. Now, after you have solved the problem, then that's the time to worry.

Richard Feynman