Blue: wenxin's comment

@ Florentin

I have edited responses 1,2,3,7 since I think the responses are on the right track. But you'll have to deal with responses 4 and 5. Response 6 too, you should already have the values. Also, as of right now, I will not edit the main paper. If there are certain ways I think you can add to the main paper, I will write it in the responses itself. As for whether or not to include them, you think about it.

As for Comment 5, my measurements show that the transmission peak value of the main cavity varies on average 3% over one minute. This percentage doesn't seem to increase or exhibit any trend even as the cavity is operated closer to concentric. For comparison, the test cavity exhibited less than 1% variation.

Reviewer #1 comments

Dear reviewer #1,

Thank you for giving us the opportunity to submit a revised draft of our manuscript to RSI. We appreciate the time and effort that you have dedicated to providing your valuable feedback on our manuscript. Here is a point-by-point response to the reviewers' comments and concerns.

- **Comment 1:** *The cavity noise spectrum is a result of the environmental noise. The author should clarify the environment for the test reported in Fig. 6. For example, if the cavity was under UHV or exposed to air, and how well the assembly was isolated from vibrations.*
  Response: The measurements were conducted in an UHV environment. The cavity rests within a glass cuvette, mounted onto our main vacuum chamber which operates at 10^{-9} mbar. The vacuum chamber is placed on an optical table stabilized from external vibrations by pneumatic isolators (Newport I-2000). Due to space constraints in the glass

cuvette, we did not mount the cavity on a passive isolation stage, thus the cavity is still coupled to vibrations from the vacuum chamber. Any components on the optical table that might introduce noise into the chamber (cooling fans, loose cables attached to the vacuum chamber) were switched off, removed from the table, or clamped down tightly. We will add this information at the end of the "Cavity alignment" section to ensure clarity as suggested.

- **Comment 2:** *Different parts of the assembly have different thermal expansion coefficients. Thus, a change in the ambient temperature can drift the cavity alignment. Have you studied the long-term drift of the cavity alignment?*

  Response: During our experiments, we observed a drift in alignment on the order of tens of minutes, which we attribute as thermal drift. The slow drift allowed us to implement an algorithm to automatically correct the cavity alignment.

- **Comment 3:** *On the first page the authors say: "To place neutral atoms at the cavity center, we use a magneto optical trap and a dipole trap in an ultra-high-vacuum (UHV) environment". This reads as if they have actually loaded atoms into this cavity. However, this is not the case in the manuscript. This needs to be rewritten to make it unambiguous.*

  Response: Well noted, we will rewrite it to avoid ambiguity. Just saying "in future experiments" in response to this comment is illogical, what is a reader supposed to get from this statement? Something like: "As we intend to use a glass cuvette (dimensions of 25 x 25 x 100 mm) rather than a large science chamber for our projects, our cavity design is limited by the size of the cuvette." is enough. And as I have said before, I still do not see the relevance of the majority of the section on "Cavity Design".

- **Comment 4:** *The authors claim "The design significantly lowers the mechanical noise compared to our previous implementation [12]". This*

is an interesting point. But they have not provided any evidence. Ref [12] did not use the same figure of merit as the current manuscript. Thus, direct comparison is not possible for the readers. This needs to be elaborated.

Response: Not sure how to address this one. He is right that it's not the same figure of merit. So far I could not find the spectral density measurements for rev1 (got rev2 a and b). Should we add a spectral density graph with rev1 to the text and mention that "the cavity in that paper displayed a noise of blah" if we find these data or? That's because the issue with rev1 is a lack of adjustment range for re-alignment after baking. I have no idea where you'll be able to dig out noise measurements for rev1.

- **Comment 5:** *The authors have assumed that all mechanical noises primarily shift the resonance frequency of the cavity. However, a transverse misalignment of the mirrors can affect the mode matching to the desired fundamental mode and change the excited cavity modes. In other words, in the transmission spectrum of the cavity, noises and misalignments can change both the amplitude and the position (frequency) of the fundamental mode. It seems that the authors have ignored any changes in the amplitude of the transmission spectrum peak of the fundamental mode. This needs clarification and needs to be justified.*

  Response: You are right that a transverse displacement of the mirrors will impact both the resonance frequency and the transmission of the cavity (it's literally stated in the question, "cavity transmission" covers both the resonance frequency and the mode coupling. Please be clearer on the distinction). While the cavity transmission is important to interface with the cavity mode (what does this mean? I don't understand), it is less significant for the length variation measurement as long as the error signal of the cavity can be resolved and the noise, resulting from it, measured (I'm just going to say that any mode decoupling from the fundamental mode also affects the noise measurement, since the conversion factor changes). For atomic experiments, the transmission

becomes of great importance (I don't see how this statement helps, either elaborate or remove). As mentioned in response to comment 2, we have developed a transverse locking scheme to palliate (why palliate again? Just write in simple english..) the decrease in transmission due to transverse displacement in a previous publication [Nguyen et al., 2018].

This response feels like dancing around the question without providing any actual answers. That said, it's a hard question, I'm still thinking of a satisfactory answer.

- **Comment 6:** *The manuscript describes the mechanical properties of the cavity assembly. The authors should consider adding some optical responses of the cavity to the manuscript. For example, the transmission spectrum and the mode waist size. They also mention the mirror reflectivity of 99.5% and the expected finesse of 627. But they should also provide the measured values of the finesse or the cooperativity based on the waist size.*

  Response: Not sure a transmission graph would be that relevant as it is quite standard? The value of the measured finesse can be added, which is ~ 323, but not sure exactly where to add yet. Would the value of the linewidth also help understanding? They are just asking what are the measured properties of the cavity, which is expected for any cavity-related papers that constructed a cavity. So probably put in the conclusions section, or in a section right after the cavity is constructed.

- **Comment 7:** *Why there are two piezos in Fig. 3, while the structure in Fig 2c shows three piezos? It seems they used two piezos for the test reported in Table 1. Is this correct?*

  Response: We apologize for the confusion, three piezos are indeed used in our cavity. We will include the third piezo in Fig. 3 to avoid confusion.

[Nguyen et al., 2018] Nguyen, C. H., Utama, A. N., Lewty, N., and Kurtsiefer, C. (2018). Operating a near-concentric cavity at the last stable resonance.