February 2, 2023

Dear Editors,

I'd like to thank the reviewer for their comments and I'll discuss in detail about the specific issues they raised and have made the corresponding changes in the manuscript when necessary.

Here is the list of detailed responses to concrete comments from Reviewer 1:

Reviewer #1's Comment #1:

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In Table I and elsewhere in the paper, the author presents a number of "neutron storage
time" results as neutron lifetime measurements. Such results were not intended to be, and
 should not be, regarded as measurements of the neutron beta decay lifetime. For example,
 in the NIST Ioffe trap experiment He-3 contamination in the superfluid helium cell
contributed to neutron losses, so the storage times were lower than the beta decay
lifetime. Similary the HOPE "lifetime results" in Table I were reported as storage times
in Ref. 34; the lifetime result is clearly presented as 887 +- 39 s, the result that
should appear in Table I. Also the tauSPECT "results" presented are not lifetime results.
 It is misleading to include neutron storage times in Table I. Those should be removed,
and this distinction should be made more clear throughout the paper.
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Response to Reviewer #1's Comment #1:

It seems that the reviewer got confused with two distinct concepts of "storage time" and "storage lifetime". Storage time is the duration during which UCNs are stored in a trap before counted, which obviously has nothing to do with the lifetime. This concept was only used in Sect. II.B , around Eq. (4) on page 9 when discussing the mfp-scaling technique used in the Mampe1989 experiment.

Storage lifetime, on the other hand, often used and reported in **magnetic** trap measurements, represents the measured lifetime before other systematic corrections such as spin-flipping, typically small, are applied. It is a particularly valid concept for magnetic trap experiments since there should be no wall losses unlike in cases of material traps. Furthermore, the UCNτ (magnetic trap) experiment even claims nearly zero systematic corrections (~ 0.17 s) or at least less than its uncertainty (see Refs. [6,9]). By comparing storage lifetime values from magnetic trap experiments, we can really see the issues regarding an anomalous dependence on trap geometry.

In the NIST Ioffe-type magnetic trap experiment, the surprisingly anomalous value of 707 ± 20 s, unpublished but presented in the dissertation, was reported not as storage lifetime but as the final measured lifetime, i.e., after all systematic corrections applied (see Ref. [20]). Indeed, there could be He-3 contamination in this experiment. But I was told by the PIs of the NIST collaboration that, though most of helium got lost by accident at the end, they managed to recover some and measured its He-3 impurity that was too low to explain their observed anomalous value. In addition, they did a simulation study using the new oscillation model and got results in agreement, as discussed in Sect. III.C on page 21.

In the HOPE magnetic trap experiment, wall loss effects similar to those in material traps were taken into account in their final lifetime value, which is a very uncommon practice for magnetic trap experiments. As a matter of fact, most of the corrections from the storage lifetime to their final lifetime value came from wall loss effects, making it questionable. On the other hand, their reported storage lifetimes show a very interesting trend, a dependence on the UCN bounce rate that could be explained under the new model, see discussion in Sect. III.C on page 22. Similar storage lifetimes were also reported preliminarily in the τSPECT experiments using a magnetic trap of similar size.

To make things clear, we added the reported final lifetime value from the HOPE experiment in Table I as the reviewer requested, but made clear in the text (in the end of 2nd paragraph from bottom on page 11) that questionable large wall loss corrections were applied in the final value, which is not typical for magnetic trap measurements. Clarification on storage lifetime was also added in the table caption.

Reviewer #1's Comment #2:

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On p6 the author states "the most feasible solution could be the newly proposed n - n'
oscillation model 141 [21, 50], which regards the "beam" lifetime as the true beta-decay
lifetime". This is not necessarily true. In one popular hypothesis, the presence of a
magnetic field oscillation resonance may cause the neutron flux in the proton trap of the
 NIST beam lifetime apparatus to be lower than that on the neutron counter, causing the
beam lifetime result to be systematically too high. While it is reasonable to suggest
that n - n' oscillation may be contributing to the neutron lifetime discrepancy, the
outcome depends on details of physics that is not yet known, so the author should not
presume at this point what the "true" beta decay lifetime is.
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Response to Reviewer #1's Comment #2:

There indeed exists another different $n - n'$ oscillation model (Ref. [48]) predicting that the beam lifetime result is higher than the beta-decay value, as the reviewer stated. But it has just essentially been ruled out by a recent work of searching such effects under magnetic fields (Ref. [49]). All these aspects on the model and the experiment were discussed in the only paragraph below Table I on page 5. Further experiments to test the new model under super-strong magnetic fields were also discussed in Sect. IV.B on page 24. Therefore, the new model discussed in this review is arguably the only viable option for $n - n'$ oscillations.

Nonetheless, we will tone down the statement, change it to the following: "... a more promising solution could be ..."

Sincerely,

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