**Reviewer#1**

The paper presents original results obtained from the HAA accelerometer on board the Juice mission during the flyby of the Earth's Moon. The paper is well written and the authors have conducted a careful analysis of the accelerometer data. In the following there are a few comments, questions and suggestions to the authors aimed at improving its scientific impact.

We thank the reviewer for the careful reading of our manuscript and appreciated the constructive comments and suggestions. The reviews helped us to improve the clarity and effectiveness of the paper. Here below we addressed all the raised issues.

On p. 4 Table 1 – the unit of the intrinsic noise floor is corrupted in the pdf file where the Square Root symbol has disappeared.

We corrected it accordingly.

On various pages there are numbers inside parentheses at the beginning of each sentence that have no obvious significance: are these the numbers of references? Please indicate them as Ref [xx] if that is the case.

We corrected it accordingly.

The legends inside the figures are often too small to be read. Please add the legends of also in the figure captions for clarity.

We corrected it accordingly.

More importantly, the analysis carried out of ripples and oscillations in the acceleration data is detailed and it does show the proper functioning of the accelerometer and rather indirectly its calibration. However, there is no explanation in the paper of the scientific impact: How does this analysis relate to the scientific goals of the 3GM experiment? Is the accuracy of these acceleration measurements enough to meet the goals of the experiment? Taking as an example the specific case of the DV of 0.7 mm/s due to outgassing, what will be the scientific impact of similar events and the associated perturbations to the spacecraft motion during the 3GM experiment?

We agree with the reviewer that the primary purpose of HAA is to support the 3GM radio science experiment and contribute to the achievement of its scientific objectives. Although HAA has already collected valuable data, the instrument is still undergoing checkout activities aimed at reaching its expected performance and accuracy. In the example, the active thermal control system has not yet been fully optimized, making it premature to assess the instrument's ultimate performance.

Nevertheless, the capability to directly measure unexpected accelerations, such as those observed during the JUICE lunar flyby, represents a significant asset for the 3GM experiment. Detecting and characterizing such perturbations can improve orbit determination and help mitigate their impact on the scientific results.

The paper will have a much stronger impact if these connections to the scientific goals were discussed in the paper.

This aspect has been added in the manuscript within the Conclusion section.

Equation (1) on p. 6 of the paper is missing a 3 to multiply the scalar product of the unit vectors R0

We corrected it accordingly.

**Reviewer#2**

**General comments:**

The manuscript presents a valuable analysis of High Accuracy Accelerometer measurements acquired during the JUICE lunar flyby. The various signals, whether expected or unexpected, are carefully examined, and the authors provide well-supported explanations for them. However, the estimation of the sublimated water mass should be strengthened and better justified. Below, I provide several comments and suggestions aimed at improving the clarity, consistency and overall quality of the manuscript.

We thank the reviewer for their careful reading of the manuscript and for their constructive comments, which helped us improve the quality and clarity of the paper. Here below the authors addressed all the issues.

**Specific comments:**

The Earth flyby immediately following the lunar flyby is not discussed in the manuscript. Did the HAA remain off, or was the closest approach too far for a relevant HAA analysis?

As the reviewer correctly pointed out, the Earth flyby took place approximately 24 hours after the lunar flyby. However, HAA was switched off about one hour after JUICE's closest approach to the Moon and remained OFF during the subsequent Earth flyby. This operational strategy was adopted because the predicted Earth flyby altitude was considered too high (6840 km above the surface) for HAA to measure any significant acceleration signal.

Page 6, line 296: Please provide a few details about the calibration of HAA data, or at least a reference.

The HAA data calibration consisted of applying a low-pass filter with a cutoff frequency of $f_c = 10^{-1}\ Hz$ to consider only frequency inside the instrument bandwidth, followed by a parabolic detrend and a correction for thermal effects induced by temperature variations. The thermal compensation step was required because the instrument's thermal control system was not activated during the measurements. This correction was performed using the thermometer readings, which were converted into equivalent acceleration signals and subsequently removed from the data. The conversion factor was determined to minimize the residuals of the calibrated acceleration after subtraction of the expected acceleration signal.

These details have been added in the text.

Page 13, lines 361-362: The authors should clarify whether HAA data was used to fit the radiometric data. Was the thermal snap modeled as discussed in section 4.2.2?

We thank the reviewer for this request for clarification. HAA data were not included in the orbital determination process, because the only available radiometric measurements were obtained in X/X band, whose accuracy provided only limited sensitivity to the spacecraft outgassing signature.

Consequently, the inclusion of HAA data in the orbit determination fit was not expected to provide any appreciable improvement in the estimation of the outgassing signal.

However, a clarification about this has been added in the manuscript.

The thermal snap has not modelled because is an event with null average, with no detectable effect on the orbit.

Page 13, lines 375-376. This sentence should also clarify what is meant by being "consistent with [...] null $\Delta V_i$.

Due to the limited quality of the X/X radiometric data, the estimated central value of the delta velocity due to the outgassing event was within the related formal uncertainty. In this sense the estimated ΔV has been stated as "consistent with null value".

Page 13, line 383-384. The authors mention that the data collected by Acc1 and Acc2 are noisier than Acc0. Nevertheless, is it possible to provide an upper bound to $\Delta V_x$ and $\Delta V_y$? Lines 405-406 indicate that they are significantly smaller. Providing bounds would help the reader.

As the authors wrote in the paper, the Acc1 and Acc2 channel are strongly affected by thermal effects degradation, which are very difficult to calibrate and disentangle from the faint outgassing signal. Due to this, is difficult to provide any quantitative information about the $\Delta V_x$ and $\Delta V_y$ using the accelerometer data.

However, because the outgassing signature is expected to occur at frequencies different from those associated with thermal distortion effects, it was possible to verify that no compatible outgassing signatures were detected in the X and Y channels that could be superimposed on the thermal signal. An upper bound for the $\Delta V_x$ and $\Delta V_y$ can be defined from the formal uncertainty of the orbit determination considering $3\sigma$:

- $|\Delta V_x| \leq$ 0.3 mm/s
- $|\Delta V_y| \leq$ 5.4 mm/s

Note that the lower value observed along the X axis is a consequence of the spacecraft line-of-sight direction being aligned with the spacecraft X axis.

The text has been updated accordingly.

Page 13-14, lines 385-403: The approach followed by the authors to estimate the mass of the sublimated water appears similar to that adopted by Sandford et al. (2020) for the Osiris-REx Sample Return Capsule,. This should be stated explicitly.

The text has been updated accordingly.

Sandford et al. (2020) report a typical value for $V_{lim}$ = 1000 m/s (the same given by the authors), associated with a range of modelled capsule temperatures. The authors of this manuscript should clarify why they chose T=300K. Given the probable location of the outgassing event, is there a more reliable estimate or measurement of the local surface temperature?

In addition, the authors should provide a reference for Eq. (7). With T=300K and R=461.5J/kg/K, I obtain $V_{lim}$ = 1056 m/s, rather than 1000m/s. The authors should also clarify why the choice $V_{sub}$ = $V_{lim}$ / 2 (line 398).

Sandford et al. (2020) state that the velocity of $H_20$ outgassing can be up to half the theoretical $V_{lim}$. Therefore, the inferred sublimated mass should be given as a range. This is currently only addressed indirectly. Please revise this section accordingly. The conclusion on line 424 should also be revised, since "around 8g" is an upper bound.

We agreed with the review that local surface temperature would be a more reliable value for the temperature at zero velocity. However, it's difficult to assess the outgassing location and even more the associated temperature.

We also want to highlight to the review that what we want to assess in the paper is an estimation of order of magnitude for the outgassed mass, for this reason we provided a sort of range for it.

It has clarified better in the manuscript.

The authors added a reference for Eq. (7). The value of $V_{sub} = V_{lim} / 2$ comes from indications given by the paper in Sandford et al. (2020), as stated by the reviewer. This value has been used to give an upper limit of the amount of mass outgassed. It has been clarified in the manuscript.

Conclusion: The potential interference cause by resonance modes of different spacecraft substructure should be mentioned in the conclusion. The authors should also state that the impact of this effect on the science results deserves further investigation, possibly in future work.

The text has been updated accordingly.

**Technical corrections:**

Please check the consistency of the vector notation in figures, equations, and text.

Page 1, lines 17-18: “JUICE will perform several flybys,including the first-ever combined Lunar-Earth Gravity Assist (LEGA), which occurred in August 2024.”. The sentence mixes future and past: “will perform” suggests that all flybys are still upcoming, whereas the LEGA already occurred in August 2024.

The text has been updated accordingly.

Page 1, line 21: “Submilimeter” -> “Submilimetre”.

The text has been updated accordingly.

Page 2, line 56: Since it is not clear whether “This phase” refers specifically to the orbital phase around Ganymede, the statement “unprecedented insights into the moons' geology” may be ambiguous. Do the authors mean Ganymede specifically, or the three outer Galilean moons more generally? Please clarify.

The text has been updated accordingly.

Page 2, line 77: “deals about” → “deals with”.

The text has been updated accordingly.

Page 4, Table 1: There is a typo in the unit of the intrinsic noise floor.

The text has been updated accordingly.

Page 4, line 160: “till” → “until”.

The text has been updated accordingly.

Page 7, Fig 4: Please add to the caption that the modelled gravity gradient is superimposed on the HAA calibrated data, so that the caption is self-contained.

The text has been updated accordingly.

Page 8, line 235: These displacements are inversely proportional to the thickness h.

The text has been updated accordingly.

Page 8, Equation (5): Please define $\Phi_{1\,AU}$ and $D_S$.

The text has been updated accordingly.

Page 9, line 263: “Here, $C_{p,f}$ and $C_{p,f}$ are” → “Here, $C_{p,f}$ and $C_{p,b}$ are”

The text has been updated accordingly.

Page 9, Table 2: Unit notations “J/kgK” and “W/mk” are ambiguous. Following the current style of the paper (e.g., Table 1), I recommend “J/kg/K” and “W/m/k”.

The text has been updated accordingly.

Page 9, line 289: “deg” → “°”.

The text has been updated accordingly.

Page 9, line 294: Please refer to the red area in Fig. 4 for clarity.

The text has been updated accordingly.

Page 10, Fig. 9: Please add to the caption that the vertical dashed lines indicate the proper modes of the different components. The MAGboom #1 and #2 should also be indicated more clearly.

The text has been updated accordingly.

Page 10, line 304: “a HAA” → “an HAA”.

The text has been updated accordingly.

Page 11, Fig. 10: Is the blue area intended to highlight the time interval during which outgassing is suspected? The figure would benefit from clarifying that, e.g., in the caption. The caption should also indicate that the red circles correspond to SWI operations.

The text has been updated accordingly.

Page 11, line 317: “Fig. above” → “Fig. 10”.

The text has been updated accordingly.

Page 11, line 318: “Submilimeter” → “Submilimetre”

The text has been updated accordingly.

Page 11, line 324: “mode” → “modes”. Additionally, the resonance modes should be formatted as “(0.44, 0.46, and 2.6 Hz)” and “(0.13, 0.21, and 0.89 Hz)”.

The text has been updated accordingly.

Page 12, Fig. 12: Please define RW in the caption: “reaction wheels (RW)”.

The text has been updated accordingly.

Page 13, line 370-371. Please specify which version of GODOT was used.

The text has been updated accordingly.

Page 13, line 373: “radio metric” → radiometric”.

The text has been updated accordingly.

Page 13, line 374. “too high covariance matrix” is imprecise. The authors should refer to specific quantities, e.g., large covariances.

The text has been updated accordingly.

Page 13, line 378: Please introduce FD as Flight Dynamics earlier in the paragraph.

The text has been updated accordingly.

Page 13, lines 381, 397. Why is DV used instead of ΔV, especially since $\Delta V_i$ and $\Delta V_y$ are used elsewhere?

The text has been updated accordingly.

Page 14, line 395. Please specify the value of the specific gas constant R.

The text has been updated accordingly.

Page 14, line 412: “sensible masses” → “proof masses”.

The text has been updated accordingly.

**Reviewer#3**

**General comments:**

The manuscript presents an analysis of the 3GM High Accuracy Accelerometer data collected during the JUICE Lunar–Earth Gravity Assist. The paper is generally well written, clearly structured, and provides valuable insights into the in-flight performance of the HAA instrument. Given the importance of non-gravitational force measurements for the JUICE mission and future scientific analyses, I believe the manuscript represents a useful contribution to the community. I have only a few comments and questions that may help improve the clarity and completeness of the paper.

We thank the reviewer for their careful reading of the manuscript and for the constructive comments, which improved the quality and clarity of the paper. Below, we address all the issues raised.

1. In Table 1, the measurement accuracy is reported as $10^{-8}$ m/s$^2$. It would be helpful if the authors could clarify whether this accuracy includes the effect of accelerometer bias at low frequencies, or if it refers solely to the high-frequency noise performance of the instrument. In my opinion, Table 1 could be further improved by including information on the expected and/or measured accelerometer bias and scale factor.

   The accuracy of $10^{-8}\ m/s^2$ is related to the bandwidth of the instrument $[10^{-4} - 10^{-1}]$ Hz. Outside the instrument bandwidth there is no requirement on the measurement accuracy.

   As per requirements the scale factor should be reconstructed within 1% of error thanks to the self-calibration, to be executed before each scientific observation. However, now is difficult to estimate this value in-flight, since the bias driven by the thermal distortion effects, with thermal control to be optimized, are superimposed on the scale factor error, which is way smaller.

   The expected measurement bias is not listed as an independent instrument performance, but it's considered to be included in the total instrument noise budget.

   Indeed, the total noise is function of the frequency and its density profile is expected to be below $8 \times 10^{-9} \frac{m}{s\sqrt{Hz}}$ between $[10^{-1}, 7 \times 10^{-4}]\ Hz$ , and between $[7 \times 10^{-4}, 10^{-4}]\ Hz$ it increases linearly up to $3 \times 10^{-8} \frac{m}{s\sqrt{Hz}}$.

Also, this performance index couldn't be tested already due to the ongoing thermal control optimization activity.

The text has been updated accordingly.

2. In Table 1, the unit reported for the intrinsic noise floor appears to contain a typo.

   Text has been corrected accordingly.

3. In Section 3, it is stated that "to reduce the down-conversion of out-of-band high-frequency signals, the HAA is equipped with an out-of-band mechanical noise rejection algorithm." Additional clarification on this point would be appreciated. Does this mechanism only suppress high-frequency disturbances outside the measurement bandwidth, or can it also suppress noise components within or below the instrument bandwidth? Furthermore, a brief description of the working principle of this mechanism, together with an indication of the expected residual error level after the noise rejection, would help readers better understand its effectiveness and limitations.

   The out-of-band signal at frequency higher than $10^{-1} Hz$ can affect HAA measurements in two ways:

   - Causing saturation at some stage of the instrument acquisition measurements chain
   - Down-converting in band due to the non-linearity of the instrument characteristic transfer function

   The instrument saturation could be detected by direct data inspection and must be avoided in any case since this would cause scientific data loss.
   The down conversion has a more subtle effect, since it cannot be distinguished from a real acceleration. However, in this case is possible to remove the out-band down-converted noise from the data, thanks to the out-of-band mechanical noise rejection algorithm. This algorithm makes use of a polynomial filter which linearizes the instrument characteristic response.
   The coefficients of the polynomial function can be found by applying a square wave with the actuators when the disturbance is acting.
   Comparing the reading of each accelerometer sensor with the expected output, it's possible to find the coefficients with a simple least square estimation.
   The residual error after the correct use of the algorithm should be comparable with the instrument total noise.

The text has been updated accordingly, however avoiding details which are out of the scope of this article, since the out of band noise reaction algorithm was not used in the data post processing.

4. Lines 284 and 285 state that “Fig. 8 shows the comparison between HAA Acc0 calibrated data after the removal of the Moon’s gravity gradient signal and the expected thermal snap acceleration”. This sentence might need to be revised as both Figure 8 and its caption indicate that the computed thermal snap acceleration is explicitly shown (in red) in the figure.

   Text has been corrected accordingly.

5. In several figures, the caption text appears rather small and is difficult to read.

   Text has been corrected accordingly.

6. I would be interested to know whether the HAA measurements acquired during the Lunar–Earth Gravity Assist could be used to estimate the accelerometer bias. In particular, during the umbra passage, when radiation pressure effects are significantly reduced and gravity-gradient contributions are relatively small, it may be possible to identify constant or linear discrepancies between the measured and modeled accelerations. Such conditions could potentially provide an opportunity to characterize or constrain the instrument bias. A brief discussion of this possibility would be valuable.

   We thank the reviewer again for this valuable suggestion. However, as noted above, thermally induced bias is currently the dominant noise source, making it difficult to estimate the intrinsic instrument bias and its rate at this stage. Once the thermal control is optimized, we expect the instrument performance to be assessed more reliably.