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Peer Review

Review of: "Untangling Magellanic Streams"

Yanbin Yang[1]

1. LIRA, Paris Observatory, Paris, France

Review report of "UNTANGLING MAGELLANIC STREAMS" by

Dennis Zaritsky, Vedant Chandra, Charlie Conroy, Ana Bonaca, Phillip A. Cargile, Rohan P. Naidu.

This report applies only to the version compiled on November 25, 2024.

This paper presents an investigation and analysis of candidates for the stellar counterpart of the Magellanic Stream (MS) using two different data sets: the H3 spectroscopic survey and the Gaia data. Based on the results, the authors conclude several properties of the MS, as presented in the abstract.

Overall, this is a highly relevant and commendable contribution to the field. However, before recommending the paper for publication, I suggest addressing the following issues. First, consider providing (statistical) significance evaluations for the detections of the 17 (or 15, if excluding the two at L_MS about -105 deg) H3 stars and the corresponding Gaia-selected sample. Second, a further discussion of modeling comparisons to link the potential stellar counterpart and the Magellanic Stream (in HI gas) would provide stronger support. I have detailed my comments below that I hope will be helpful in strengthening the authors' conclusions.

Comments on statistics:

It is impressive that 17 candidates (or 15, if excluding the two at L_MS about -105 degrees) have been detected from the H3 survey. Though the number is small, the detection seems real based on Fig. 2, assuming the H3 survey is homogeneously sampled and complete to a given magnitude. Additionally, this detection confirms the results reported in their previous paper Zaritsky et al. 2020b (Z20). I suggest the authors provide a statistical significance measure for the clustering of the stars.

Please plot color bars of counts and indicate the relevant values in Figs. 4, 5, and 6.

The stars selected from the Gaia data in Fig. 5 are supposed to be candidates of the stellar counterpart of the sub-dominant strand. Please clarify the contamination from the Milky Way (MW) stars, e.g., which fraction of stars is expected to be associated with the sub-dominant strand, together with its statistical significance evaluation.

Comments on the comparison with modeling:

The paper draws conclusions about the properties of the MS in HI gas through the analysis of its possible stellar counterpart. Four key points are outlined in the abstract, of which "(3) the subdominant strand is tidal in origin" appears to be the most crucial one. Once this point is convincingly justified, the others follow naturally. Therefore, a self-consistent model facilitating discussion of the link between gas and stars is essential. However, I find the current discussion in the paper unconvincing, as detailed below.

In principle, the detection of 15 H3 stars (within -83 < l_MS < -75 degrees) presented in the current paper is a confirmation of the Z20 detection. These stars are located at R_GAL about 50 kpc on average (below 70 kpc overall, see Fig. 8 in the current paper), so they are not compatible with the tidal model of the MS by Besla+2012 (see Fig. 7 in Chandra+23). The authors also have clarified this point in the introduction (the last sentence of the penultimate paragraph).

Alternatively, the authors suggest a potential explanation for the 15 H3 stars by referencing the simulation by Diaz & Bekki (2012). However, caution must be exercised due to two key limitations: 1) their simulations assume two passages of LMC-SMC in the MW, which is not consistent with the consensus that LMC-SMC are on their first in-fall (e.g., Besla+2012); 2) their simulations do not include a gas component. Consequently, it remains unclear whether the HI gas in these simulations could account for the observed properties of the MS in HI, particularly when considering further the strong ram pressure impact from the MW's circumgalactic gas, as recently reviewed by Lucchini et al. (2024).

Thus, without showing a self-consistent model that includes both star and gas (or discussing a potential solution), it will be difficult to link the 15 stars to the MS in HI. For example, there is a statement in the 3rd paragraph of Sect. 4 (Discussion) - "The subdominant MS strand investigated in the present work shows a close correspondence between stars and gas in the detailed density structure along the filament. The presence of stars confirms that this gaseous filament is a tidal feature. ...". I did not find how this conclusion is justified because if I adopt the Besla+2012 model, I find that the 15

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stars cannot match the distance that is predicted by the model; if I adopt the model by Diaz & Bekki 2012, there is no gas component to check for convincingly deriving the conclusion.

I understand that the Gaia data is subsequently examined (e.g., Fig. 5) to find potential stars in support of the authors' argument and conclusion. However, due to the lack of significance testing and the evaluation of the MW contamination, it will be difficult to validate the findings (this relates to my previous comment on statistics).

Minor comments:

1) When selecting the Gaia sample in Sect. 2.2, removing known QSOs might be helpful.

2) The H3 survey is designed for stars within the magnitude range of $15 < r < 18$, while the Gaia sample is selected down to 18.5 in the Gaia G-band. In Fig. 3, the bottom panel, one may notice a clear deficiency of stars when $G > 18.0$. Could the authors explain the underlying reasons, particularly why the Gaia selection extends 0.5 mag deeper than the H3 limit? My understanding is that this additional selection could introduce more contamination into the later statistical analysis.

Declarations

Potential competing interests: No potential competing interests to declare.

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