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Peer Review

Review of: "Untangling Magellanic Streams"

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The paper presents a compelling investigation into the Magellanic Stream (MS), identifying two distinct strands using a combination of high-resolution spectroscopic data from the H3 Survey and astrometric data from Gaia DR3. The identification of a subdominant stellar strand, attributed to tidal stripping from the Small Magellanic Cloud (SMC), is a significant step forward in unraveling the complex structure of the Magellanic Stream. Additionally, the finding that the dominant gaseous strand appears devoid of stars within 55 kpc adds a new dimension to our understanding of these features. The study is a contribution, but several aspects could benefit from further analysis and clarification to increase the impact of the conclusions.

The authors' reliance on Gaia DR3 data, particularly proper motions and photometric distances, introduces potential challenges that merit further discussion. While Gaia's proper motions are relatively reliable at the distances considered, its parallaxes and photometric distances are less so, particularly beyond a few kiloparsecs where uncertainties and biases become significant. Although the authors mitigate contamination through parallax cuts, the potential for foreground stars with unreliable solutions remains. Similarly, Gaia's photometric completeness at faint magnitudes ($G>16.6$) is not explicitly addressed, leaving open the possibility of biases in the selection of distant stars. These limitations should be quantitatively assessed to enhance the reliability of the findings.

The interpretation of the subdominant strand as a tidal feature raises intriguing possibilities but would benefit from further investigation. While the spatial correlation between stars and gas is suggestive, alternative mechanisms such as ram pressure stripping should be more thoroughly discussed. Additionally, the sample size of nine H3 stars, while informative, is small, and the authors have not demonstrated whether the observed chemical abundances are statistically distinguishable from the broader Milky Way halo population. A coherent velocity gradient analysis, a key feature of

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tidal streams, is absent and could provide a stronger basis for the tidal interpretation. Strengthening the argument with quantitative simulations or tempering the conclusions would enhance the credibility of the results.

The characterization of the dominant strand as devoid of stars within 55 kpc is thought-provoking but warrants a closer look at observational limitations. The lack of stars may reflect selection biases in Gaia and H3 rather than an intrinsic property of the strand. Studies such as Chandra et al. (2023) indicate the presence of stars at larger distances (60–120 kpc) that may be associated with the dominant strand. A discussion of these findings, along with the observational constraints, would provide a more nuanced interpretation.

The identification of stellar overdensities in the Gaia data, aligned with the subdominant strand, is intriguing but could be made more robust by addressing the statistical significance. While the authors utilize a mock Gaia catalog as a control, the analysis is limited to spatial distributions and does not incorporate kinematic or chemical comparisons, which would significantly strengthen the association between these stars and the Magellanic Stream. A more comprehensive analysis addressing halo contamination and comparing with simulated halo star distributions would be particularly valuable.

Another critical consideration is the potential contamination from the Sagittarius (Sgr) stream, which is briefly mentioned but not thoroughly analyzed. Given the proximity of the Sgr and Magellanic Stream regions on the sky, and the potential for significant offsets in early-stripped debris (e.g., Vasiliev et al. 2021), a detailed analysis is essential to ensure the robustness of the conclusions.

The relationship between the HI "archipelago" and the subdominant strand is intriguing but underdeveloped. Exploring whether the alignment between gaseous features and Gaia-selected stars is physical or coincidental is an important point to address for the study. Including simulations to probe this relationship would greatly enhance the discussion.

Finally, the paper would benefit from stronger engagement with the existing literature. Key studies, such as those by Lucchini et al. (2020), Pardy et al. (2018), and Fox et al. (2013), provide critical context for understanding the bifurcation of the Magellanic Stream and the chemical properties of its components. Incorporating these works would situate the study within the broader context.

Declarations

Potential competing interests: No potential competing interests to declare.

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