

Review of: "Slow diffusion around pulsar γ -ray halos and its impact on cosmic rays propagation"

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Potential competing interests: No potential competing interests to declare.

I have thoroughly read your manuscript and found the following critical questions and points of clarification for the manuscript titled "Slow diffusion around pulsar γ -ray halos and its impact on cosmic rays propagation" by Xiaojun Bi:

- 1. Abstract Clarity:** The abstract provides a brief overview of the study's findings, but it would be helpful to include a concise statement of the main hypothesis or research question being addressed.
- 2. Motivation and Significance:** What motivated this study, and why is it significant? Clearly articulate the gap in knowledge or the problem that this research addresses.
- 3. Data and Methodology:** Provide a detailed explanation of the data sources and methodology used in the study. How were the diffusion coefficients measured or estimated, and how were the surface brightness profiles obtained?
- 4. Comparison with Previous Research:** Discuss in more detail how this study builds upon or differs from previous research on pulsar γ -ray halos and cosmic ray propagation, particularly in relation to the ballistic-diffusive (BD) propagation scenario.
- 5. Validity of Slow Diffusion:** What evidence is there to support the assertion that slow diffusion is necessary? Are there alternative explanations for the observed differences between the BD and slow diffusion scenarios?
- 6. Physical Mechanisms:** Can you elaborate further on the physical mechanisms that drive slow diffusion around pulsar γ -ray halos? Are there specific factors influencing this phenomenon, such as magnetic fields or particle interactions, that need to be discussed in more detail?
- 6. Impact on Cosmic Rays:** Elaborate on the specific ways in which the slow diffusion region around pulsars impacts cosmic ray propagation. What are the implications for our understanding of cosmic ray physics?
- 7. Positron Excess:** Provide a more detailed explanation of how the slow diffusion region affects the contribution of positrons from nearby pulsars to the AMS-02 data and its relevance to explaining the positron excess.
- 8. Dark Matter Scenario:** Explain the dark matter scenario in more depth. How does the slow-disk diffusion model influence the constraints on dark matter annihilation, and what are the implications for this model's feasibility?
- 9. Model Assumptions:** Are there any critical assumptions or simplifications made in the slow-disk diffusion model or the

dark matter scenario that could affect the results? Discuss potential sources of uncertainty.

10. Comparison to Observations: Provide a more comprehensive comparison of the model's predictions to observational data, including not only AMS-02 but also other relevant measurements.

11. Comparison of Models: In your comparison of the BD and slow diffusion models, have you considered alternative explanations for the observed discrepancies? Are there other parameters or factors that might be affecting the model's predictions?

12. Robustness of Slow Diffusion Model How sensitive are your results to the choice of parameters in the slow diffusion model? Have you conducted sensitivity analyses to assess the robustness of your conclusions?

13. Cosmic Ray Anisotropy: You mentioned that the slow disk model suppresses cosmic ray anisotropy. Can you provide more insight into the implications of this suppression and how it aligns with observations?

14. Dark Matter Constraints: While your study suggests that the dark matter scenario remains feasible in the slow-disk diffusion model, are there specific constraints on the properties of dark matter particles that should be discussed? How do these constraints compare to other independent constraints from astrophysical observations?

15. Uncertainty Quantification: Have you quantified the uncertainties associated with your model predictions, especially in the context of the slow-disk diffusion model? How do these uncertainties affect the precision of your conclusions?

16. Temporal Evolution: Does the slow diffusion phenomenon exhibit any temporal evolution? Are there instances where pulsars transition from slow diffusion to fast diffusion or vice versa, and if so, what are the implications for cosmic ray propagation?

17. Comparison with Observational Surveys: Have you compared your model predictions with other observational surveys beyond AMS-02? Considering the importance of multi-messenger astrophysics, are there data from other experiments that support or challenge your findings?

18. Discussion of Implications: Could you elaborate on the broader implications of your findings for our understanding of the Milky Way's cosmic ray environment and its relevance to broader astrophysical questions?

19. Experimental Confirmation: Are there ongoing or planned experiments or observations that could provide experimental confirmation or refutation of the slow-disk diffusion model or other aspects of your study?

20. Interpretation of Results: How do you interpret the fact that slow diffusion regions exist around pulsars in the Milky Way? What does this tell us about the interplay between pulsar physics, cosmic ray propagation, and the broader astrophysical context?

21. Generalizability: Can your findings on slow diffusion be generalized to other galaxies or astrophysical environments, or is it specific to the Milky Way? What implications might this have for extragalactic astrophysics?

22. Caveats and Open Questions: In your conclusion, are there any caveats or open questions that you would like to

highlight, particularly those that might require further investigation in future studies?

23. Discussion of Limitations: What are the limitations of this study, and how might they affect the validity of the conclusions? Are there uncertainties in the model parameters or assumptions?

24. Future Work: Conclude the manuscript by suggesting potential avenues for future research in this area, especially any unresolved questions or aspects that require further investigation.

25. References: Ensure that all references are up to date and that recent relevant research in the field is included.

Addressing these questions and points of clarification will help strengthen the manuscript and provide a clearer understanding of the research and its implications.

Corollary/ Decision: The manuscript in the present form is not acceptable in the journal for publication unless and until all the queries above are successfully answered.