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

Arun Kumar Pandey[1]

1 Max Planck Society

Potential competing interests: No potential competing interests to declare.

Introduction: The research paper titled "Slow Diffusion and Pulsar Gamma-Ray Halos: A Critical Analysis" explores the role of slow diffusion in accounting for pulsar gamma-ray halos. The authors propose a two-zone diffusion model, where a small region around the pulsar exhibits slow diffusion, while the rest of the diffusion follows regular values. The paper also investigates the impact of slow diffusion on positron flux and examines the compatibility of the dark matter scenario with the new propagation model.

Summary of Findings: The authors find that the ballistic-diffusive (BD) propagation, without slow diffusion, fails to explain the gamma-ray halo profiles effectively. They demonstrate that slow diffusion is necessary to account for the pulsar gamma-ray halos. The study also suggests that the contribution of positron flux from nearby pulsars, particularly Geminga, is enhanced in the two-zone diffusion model compared to the conventional fast diffusion model. Additionally, the dark matter scenario is shown to satisfy all constraints on the annihilation cross-section in the new propagation model.

Questions need to be addressed:

While the research paper provides valuable insights into the role of slow diffusion in pulsar gamma-ray halos, there are several areas that require further clarification and elaboration. The following questions should be addressed to enhance the clarity and comprehensiveness of the paper:

1. **Methodology:** Could you provide a detailed explanation of the methodology used to calculate the diffusion coefficient and derive the surface brightness profiles of the gamma-ray halos? This information would help readers understand the reliability and accuracy of the results.
2. **Comparison with Previous Studies:** How does your two-zone diffusion model compare to previous models proposed in the literature? Are there any significant differences or improvements in terms of explaining the observed gamma-ray halo profiles and positron flux?
3. **Impact of Slow Diffusion Region:** What are the specific mechanisms or physical processes that lead to the suppression of diffusion in the slow diffusion region around pulsars? It would be beneficial to delve deeper into the underlying physics and provide a more detailed explanation of this phenomenon.
4. **Sensitivity Analysis:** Have you conducted a sensitivity analysis to assess the robustness of your results? It would be valuable to investigate how variations in key parameters, such as the diffusion coefficient or the size of the slow diffusion region, affect the gamma-ray halo profiles and positron flux predictions.

5. **Comparison with Observational Data:** How well do the predictions of your two-zone diffusion model align with observational data, such as gamma-ray halo profiles measured by HAWC or positron flux measurements from AMS-02? Providing a quantitative comparison would strengthen the validity of your model.
6. **Limitations and Future Directions:** What are the limitations of your study, and what avenues for future research do you suggest? Are there any additional factors or phenomena that should be considered to further refine the understanding of pulsar gamma-ray halos and their implications for cosmic ray propagation?