

The manuscript “*Study of Temperature Anisotropy and Kappa Distribution Impacts on EMIC Waves in Multi-Species Magnetized Plasma*” by us. The goal is to respectfully address all concerns and emphasize the novelty and improvements made, aiming for acceptance

Response to Referee # 2 Comments

We sincerely thank the reviewer for the detailed and insightful comments. We have carefully revised the manuscript to address all the points raised. Please find our point-by-point responses below.

Comment 1: Missing references (Gary and Wang 1996, Chen and Hasegawa 1974 etc.)

Response:

We appreciate the reviewer pointing this out. The following key references have now been **included** in the revised reference list:

- Gary, S. P. and Wang, J.: Whistler instability: Electron anisotropy upper bound, *J. Geophys. Res. Space Phys.*, 101, 10749–10754, <https://doi.org/10.1029/96JA00326>, 1996.
- Chen, L. and Hasegawa, A.: A theory of long-period magnetic pulsations: 1. Steady state excitation of field line resonance, *J. Geophys. Res. Space Phys.*, 79, 1024–1032, <https://doi.org/10.1029/JA079i007p01024>, 1974.

We also conducted a thorough cross-check to ensure that all in-text citations are now correctly reflected in the reference list.

Comment 2: Referencing issues duplicate listings (e.g., Lazar et al. 2006)

Response:

Thank you for this observation. We have carefully reviewed the entire reference list and removed any duplicate entries. Specifically, *Lazar et al. 2006* now appears only once in the bibliography and is cited properly in the text. We also corrected similar issues elsewhere to maintain one-to-one consistency between citations and references.

Comment 3: Reference source errors (“Error! Reference source not found.”)

Response:

We regret the oversight. The reference link error in lines 197–198 has been corrected.

Comment 4: Undefined symbols in “Basic Trajectories” section

Response:

We thank the reviewer for pointing out this clarity issue. In the revised manuscript:

- All symbols and notations are clearly defined at their first instance.

- Transitions between equations are now explained in text to improve logical flow and reader comprehension.

Comment 5: Frequency terms in Equation 16 (Distribution Function)

Response:

Reviewer is correct that a *general* velocity distribution should not include wave parameters. However, in the context of wave-particle resonance analysis, the inclusion of ω is appropriate because the distribution is being evaluated at a resonance velocity defined by wave properties. The form is consistent with standard treatments in plasma wave theory (e.g., Stix, 1992)

Comment 6: Inconsistent units and symbol usage

Response:

We have thoroughly reviewed and standardized all units and symbols:

- The unit for time is now consistently written as s (not S).
- The wavevector is uniformly denoted as K_{Π} .
- The Kappa parameter is written as k_p , distinct from the wavevector notation to avoid confusion.

the formatting issues in the graph notations of the spectral index and the wave vector . The graphs were generated using Microsoft Excel, which has limited support for advanced mathematical notation particularly for rendering Greek letters and subscripts in axis labels and legends.

As a result, symbols like k_p and K_{Π} may appear in plain text format (e.g., "Kp" or "**K**_Π") rather than in proper scientific notation. While we have attempted to maintain clarity within the constraints of Excel, we ensured that all symbols are explicitly defined in the figure captions and the main manuscript text to avoid ambiguity.

Comment 7: Growth rate vs frequency graph

Response:

We thank the reviewer for the helpful suggestion. While a *growth rate vs. frequency* plot can effectively show unstable EMIC bands, we chose to present *growth rate vs. wave vector* to focus on spatial instability scales and the resonance condition which is central to our multi-ion kappa distribution analysis. This approach captures the key instability features through the dispersion relation linking ω and K_{Π} . We agree that a frequency-based plot would add value and will consider it in future work.

Response to Referee # 2 Comments

Comment 1: Lack of nonlinear effects and insufficient novelty

Response:

We sincerely appreciate the reviewer's feedback on the manuscript. We understand the concern regarding the lack of nonlinear effects in the analysis of EMIC waves within Kappa distributions. While this study focuses on the linear growth rates, we acknowledge that nonlinear effects are important in understanding the full behaviour of EMIC waves. We plan to explore these nonlinear effects in future studies, employing advanced methods such as Particle-in-Cell (PIC) simulations or other nonlinear modelling approaches.

Regarding the novelty of the physics relationships in Kappa distributions, we respectfully disagree with the assertion that previous studies do not highlight the contributions of this work. Our study presents a novel exploration of EMIC wave propagation in a multi-ion plasma under the influence of the Kappa distribution, incorporating new insights into the growth rates and resonant energies for a multi-species plasma. We have further clarified how our results differ from and extend the works of Lazar *et al.* (2006), Hellberg *et al.* (2009), and Xue *et al.* (1993, 1996a, 1996b). The distinctions from prior work are clearly outlined, particularly in the context of the temperature anisotropy

We believe that the manuscript provides valuable contributions to the understanding of linear wave growth in Kappa-distributed plasmas and can serve as a foundation for future work on the nonlinear effects. We respectfully request the reviewer to reconsider the rejection, as we are confident that the current study offers novel insights into EMIC wave dynamics, which can be expanded upon in subsequent studies."

Conclusion

We hope that the substantial improvements made to the manuscript in response to all reviewer concerns particularly the corrections to referencing, equation consistency, physical clarity, and the addition of new results meet the standards for publication. We are grateful for the opportunity to revise and thank the reviewer for helping us improve the clarity and rigor of our work.