Dear Editor,

We sincerely thank you for handling our manuscript and for the opportunity to revise it. We also express our gratitude to the reviewers for their careful evaluation and constructive feedback, which have significantly improved the quality and clarity of our work. In response to their comments, We have conducted a major revision of our manuscript. The main changes are summarized as follows:

- Clarified the novelty of the current work compared to our previous study, emphasizing new results, discussion, and comparison between the modified and standard Kappa distributions.
- Rewritten the abstract and conclusion to focus on the key findings and their significance.
- Shortened or removed content previously presented in the earlier paper while retaining essential background for context.
- Added discussion on the physical motivations for using the standard Kappa distribution, and updated the kappa-dependence of the thermoelectric coefficient and effective collision frequencies.
- Revised figures, captions, and tables to improve clarity, added units/normalizations where necessary, and clarified valid parameter ranges.
- Corrected all typographical, stylistic, and reference errors, ensuring consistency in notation, equations, and citations.
- Included additional discussion comparing results with literature and highlighting ongoing work on Regularized Kappa Distributions (RKD).

We believe these revisions substantially improve the clarity, structure, and scientific positioning of the manuscript, and we hope the revised version now meets the journal's standards.

Thank you again for your time and consideration.

Response to Reviewer # 1 Comments

We sincerely thank Reviewer # 1 for the careful and critical reading of our manuscript and for his respected suggestions. Below we address each point in detail.

Major Comments

1. *Novelty vs Paper I*
2. *Abstract focus*
3. *Length and role of Section 3*

All three points revolve around similar ideas. The manuscript does not clearly distinguish new contributions from Paper I; the SK results may already be implicit. In the revised manuscript, we focus more on the results, discussion, and comparison between the modified and standard kappa distributions. This was achieved by removing or shortening parts that were already presented in Paper I. The revised manuscript also emphasizes motivation and context rather than methodology. Additionally, we rewrote the abstract and the conclusion to focus more on the results and the comparison between the MK and SK distributions.

4. *Length and redundancy of Section 2*

It's true that this section contains a lot of points that have been discussed in earlier work, but it is still important to include it in the current study. This section is crucial for discussing the results obtained in the next sections, and it will make it easier for the reader to relate the results of the paper to the shape of the distributions.

5. *Interpretation of Figure 10 and comparison with literature*

In the manuscript, we compared our results for the standard Kappa distribution with the only available reference that, to our knowledge, has calculated the transport coefficients for the same distribution. The comparison shows agreement in behavior.
A similar approach was used in Paper I, where a comparison was made between the transport coefficients for the modified Kappa distribution from our work and those obtained using other models that employ more advanced collision terms than the Krook model, but less complex than the Boltzmann collision term. These studies also exhibited similar behavior (see Fig. 9 in the revised manuscript). Therefore, the literature supports the validity of our results for both distributions considered separately.
Furthermore, to our knowledge, no comparison of transport coefficients between the two distributions has been made, except for Husidic et al. (2021). A discussion have been added in the revised manuscript to explain why the ordering differs from that reported in Husidic et al. (2021).

6. Introduction and the Motivation for SK

In the revised manuscript, we have added a discussion on why SK is needed and whether it is more realistic, along with references to works where SK has been used successfully to improve the clarity of the introduction.

7. κ-independence of thermoelectric coefficient

This is the most important and critical point in the review, so we thank the reviewer for noticing it and bringing it up, as it has a high impact on the results. This change affects the kappa dependency of the thermoelectric coefficient. The comment highlights something important that we did not take into account when writing the five-moment approximation system, namely that the temperature should have a kappa dependency, which results in a change in the thermoelectric coefficient. In the revised manuscript, we address this problem along with the updated five-moment approximation system and the revised kappa-dependent thermoelectric coefficient.

Minor Points

1. **Comment:** *The current title of the manuscript is rather generic and does not clearly highlight how this work differs from previous studies with similar titles on transport theory in Kappa-distributed plasmas. I suggest that the authors consider a more specific title.*

   Response: we have slightly changed the title.

2. **Comment:** *Lines 47 and 53: All of the reviewed studies... and Thus, all reviewed works...: Strictly speaking, these statements are not entirely accurate, since the manuscript also cites Paper I along with the studies that used simpler approaches.*

   Response: We have removed the reference (Jwailes et al., 2025) from the statement.

3. **Comment:** *Line 49: The acronym "BGK" is not defined.*

   Response: We have removed it since the use of the Krook-type operator is more appropriate after reviewing the references.

4. **Comment:** *Lines 97,115: The acronyms SK and MK are introduced but not used elsewhere in the text. They should either be removed or consistently used throughout the manuscript. I recommend following the standard practice of using the acronyms after their introduction, which would make the text easier to read.*

   Response: Thank you for the comment. The acronyms SK and MK were introduced to denote the corresponding mathematical symbols and are used in the figures (effective collision frequency, thermalisation rate, and relative temperature difference). However, because SK and MK are very similar, repeated use of these acronyms in the main text could confuse the reader. Therefore, we deliberately avoided using the acronyms throughout the text and instead used the full terms for clarity, while retaining the symbols in the figures.

5. **Comment:** *Eq. (3): Is it correct to use the species subscript s also for v?*

Response: Yes, the subscript s should be used for only v because each species has its own velocity distribution. that can be seen in the (Schunk, R. and Nagy, A.: Ionospheres: Physics, Plasma Physics, and Chemistry, Cambridge Atmospheric and Space Science Series, Cambridge University Press, 2009)

6. **Comment:** *Line 99: thermal velocity: Since this is not a vector quantity, would "thermal speed" be more appropriate? Furthermore, it should be noted that the term can be ambiguous. For example, some authors (e.g. Olbert, Vasyliunas, Huang) refer to Eq. (2) in the manuscript as the most probable speed, while "thermal speed" is reserved for other expressions (see textbooks on thermodynamics and statistical physics).*

   Response: We have changed it across the revised manuscript to "thermal speed," which is more appropriate.

7. **Comment:** *Lines 106-108: It would be helpful to include one or two citations where an interested reader can find details.*

   Response: we add a reference in revised manuscript

8. **Comment:** *Line 109: Strictly speaking, as κ increases but remains finite, the Kappa distribution does not fully reach the MD. It would be more precise to state that the MD is recovered in the limit $\kappa \to \infty$.*

   Response: We have changed the word "reaches" to "approaches."

9. **Comment:** *Line 119: The use of the term "invariant" is unclear here, since κ_{0_s} changes as κ_s varies.*

   Response: The word invariant is part of the symbol κ_0 name, as it's called the invariant kappa index, see the following references (Livadiotis, G.: Kappa distributions: Thermodynamic origin and Generation in space plasmas, 1100, 012 017, https://doi.org/10.1088/1742- 6596/1100/1/012017, 2018)

10. **Comment:** *Line 146: The authors could consider rephrasing for more clarity, for example "...both the MK and SK exhibit suprathermal (or enhanced) tails compared to the Maxwellian distribution".*

    Response: we rephrase it as suggested.

11. **Comment:** *Figure 1 and others: The units or normalisations used for the plotted quantities are not specified. Even indicating "arbitrary units" would improve clarity.*

    Response: we Added units/normalisation (or specified "arbitrary units") to all relevant figures.

12. **Comment:** *Figure 1: The authors should consider whether the figure is necessary, as Fig. 2 seems sufficient to illustrate the trends and differences between the MK, SK, and MD.*

    Response: We prefer to keep the figures because they show how, for different kappa values, each case approaches the Maxwellian distribution.

13. **Comment:** *Figure 2: The authors may wish to consider using a logarithmic scale for the ordinate axis, as in Lazar et al. (2016), to better illustrate the differences in the*

high-energy regime between the distributions.

Response: We prefer to keep it as it is, since most of the references already use the logarithmic scale to show the differences in the tails, so the reader can easily see them. Second, the logarithmic scale shows the differences in the tails but shrinks the cores, which is a very important difference for the discussion in other sections.

14. **Comment:** *Lines 157-163: It would be helpful to provide citations to support the statements.*

    Response: Added supporting citations.

15. **Comment:** *Line 190: The quantity M is not defined when it is first introduced in Eq. (11).*

    Response: its defined along with the symbol $\delta\mathbf{M}_s/\delta t$ as one not $\mathbf{M}_s$ alone

16. **Comment:** *Line 193, coordinate space: In this context, velocity (or momentum) components are also considered coordinates. The authors may wish to consider a clearer formulation.*

    Response: we have changed it to , in spatial coordinates

17. **Comment:** *Lines 293-301: It is somewhat confusing to read that the authors start with a drifting SK, but then immediately neglect the drift.*

    Response: We modified the paragraph to indicate that, in a Lorentz plasma, the ion drift velocity is neglected, while the electron drift velocity is assumed small compared to the thermal speed.

18. **Comment:** *Figure 3: It would be helpful to explicitly indicate the κ -dependence so the figure is understandable on its own (or refer to an equation in the caption).*

    Response: we changed the caption

19. **Comment:** *Figure 3: Since $\kappa > 3/2$ is required, it might be clearer not to plot the κ -dependence for values below this threshold.*

    Response: The mathematical condition for Coulomb collisions is $\kappa > \frac{1}{2}$, so Figure 3 starts at $\kappa = \frac{1}{2}$ to show the full valid range of the collision operator. The stricter condition $\kappa > \frac{3}{2}$ ensures that the distribution temperature remains finite and also appears in other models, such as Maxwell molecules, as a direct mathematical requirement. Since Figure 3 aims to illustrate the general κ-dependence across the complete admissible domain of Coulomb collisions, the range beginning at $\kappa = \frac{1}{2}$ is retained.

20. **Comment:** *Figure 10: For consistency, the authors should clarify in the caption and main text that this figure refers to Coulomb collisions.*

    Response: Clarified in caption and text that it refers to Coulomb collisions.

21. **Comment:** *Tables 2, 3, 4: The authors should consider moving these tables to an appendix, as the information may interrupt the flow of the main text and is largely available from the discussion.*

    Response: We prefer to keep them as they are, since they give a very good summarization for the new reader on this topic.

22. **Comment:** *The authors should ensure that all references include correct and appropriate links. For example, the link for Lazar & Fichtner (2021) does not direct to the actual source on the Springer website, and other links such as Livadiotis (2018) are broken.*

    Response: Checked and corrected all links to ensure they direct to the proper sources.

Technical Corrections

All typographical and stylistic corrections have been implemented, including:

- grammar and punctuation fixes,
- consistent equation formatting (we used parentheses and "Eq." or "Eqs." for all equations),
- improved clarity and readability, as much as possible.

Only in point 11, in the second part, we kept the s and t as they are. We prefer to keep the notation as is to maintain consistency with the notation used in the first paper.

We thank the reviewer again for the thorough and insightful comments. The suggested revisions will significantly improve the clarity, structure, and scientific positioning of the manuscript.

Response to Reviewer # 2 Comments

We sincerely thank Reviewer # 2 for the careful and critical reading of our manuscript and for his respected suggestions. Below we address each point in detail.

Major Comments

1. Clarification of collision processes

In the revised manuscript (second paragraph in subsection 3.2), we add a short paragraph summarizing the key physical differences among Coulomb collisions, hard-sphere interactions, and Maxwell-molecule collisions.

2.Behavior of the effective collision rate (Eq. 57 and Fig. 3)

Does that result mean that a plasma described by a SK distribution has negligible collision rates at small kappas?

Yes, that is exactly what the effective collision frequency indicates: the SK distribution has a very low collision rate compared to the Maxwellian when we are dealing with Coulomb collision interactions. At low values of kappa, most particles are in the tails, and the core of the distribution becomes very low. A similar dependency was found in Scherer et al. (2020) (https://academic.oup.com/mnras/article/497/2/1738/5868832) for the Debye length, which, in the revised manuscript (Appendix A), we linked it the effective collision frequency, showing the same kappa dependency obtained in this work.

3. Comparison with Solar Wind measurements

We agree that comparison with observational data is highly valuable. While such an analysis is beyond the scope of the present work, we add a discussion highlighting this point at the end of the conclusion. We also note that a detailed comparison between SK and MK predictions and in-situ measurements will be the subject of future work.

4. Regularized Kappa Distribution (RKD) and comparison with Husidic et al. (2022)

The study of transport coefficients using the Regularized Kappa Distribution (RKD), along with a detailed comparison to the results reported by Husidic et al. (2022), is currently being carried out in a separate work. A brief note has been added to the manuscript to clarify that this analysis is ongoing and to highlight its relevance to the present study.

Minor Comments

- Typographical errors and grammar mistakes in points 1, 3, and 4 have been corrected.
- We appreciate the suggestion regarding Figures 1 and 2. We prefer to keep them as they are, since most of the references already use a logarithmic scale to show differences in the tails, allowing the reader to easily observe them. Additionally, the logarithmic scale highlights differences in the tails but compresses the cores, which is a very important distinction for the discussion in other sections.
- For the standard Kappa distribution, it is true that mathematically the distribution itself is defined for $\kappa > 1/2$, but it is still physically undefined because the effective temperature at this value of κ is not defined. We have carefully reviewed the statement and rewritten it to clarify that this is a physical condition, see 556-560 in the revised manuscript.

We thank the reviewer again for the thorough and insightful comments.