

Interactive comment on “Invariants of the Spatial-Energy Structure and Modeling of the Earth’s Ion Radiation Belts” by Alexander S. Kovtyukh

Anonymous Referee #2

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##General comment

The review written by the author and published last year in the journal Space Science Reviews (SSR) concluded that there is a need for the development of radiation belt heavy ion empirical models. The submitted paper gathers available heavy ion measurements obtained all over the space age and tries to pave the way for the development of such models. To do so, invariant parameters (that are constant over a given range of L) are detailed and available measurements are shown on Figures and discussed in detail. The solar cycle variation of heavy ion fluxes is for the first time explored in the submitted article. Finally, the presented measurement database is im-

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portant to explore the physical mechanisms that govern the heavy ion radiation belts, what is done by the author in sections 3 and 4. Comparative lessons with what is known for the protons are drawn.

There is no doubt that the work presented here is important and may contribute to advances in our understanding and prediction of the heavy ion radiation belts. The submitted article may therefore, according to the reviewer, be ultimately published after several clarifications. The article needs to first be edited for English, in order to make it easily understandable so that it would have an impact on the work of others. The reviewer is then wondering: what is new in this article, compared in particular with the review published in SSR last year (see specific comments)? I recommend the article to be revised and reviewed again to see if, after English proof and clarifications, the article would be suitable for publication in Annales Geophysicae.

##Specific comments

Section 2: would it be possible to clarify if the invariant parameter values given here come from previous publications or are the outputs of the new study? The values reported here are very important. If the values have now been recomputed or updated, would it be possible to have them highlighted in a table, for instance? A possible use from other researchers would be to compare them with what has been observed by now two orbiters around Jupiter, as these orbiters performed numerous observations of trapped heavy ions (helium, oxygen, sulfur).

Would it be possible to remind, with maybe one sentence, the criterion used to select quiet periods over which the measurements are averaged?

The measurements are averaged near solar cycle minimum and near solar cycle maximum. Are the measurements very dispersed around this average in each case or are the standard deviations small compared to the shown averages? A comment may be added in the main text about this.

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The dataset of heavy ion measurements is limited, but is it large enough to conclude if there is any observable Magnetic Local Time asymmetry in the heavy ion radiation belts, in particular at the lowest considered kinetic energies?

Section 4: What are the new conclusions on the physics of the heavy ion radiation belts? If you confirm what has already been reported in previous publications, would it be possible to add a sentence to state it? Otherwise, new findings may be more highlighted in this section and in the conclusion.

Lines 453-454: "Here, the experimental database is significantly expanded, many modern measurements of the ion fluxes of the ERB have been added", what are the modern heavy ion measurements added since the article published by the author in 2001? For the protons, one can see the GEO-3 and Van Allen Probe observations, however there does not seem to be any "modern" measurement of heavier ions.

##Technical corrections

The article needs to be edited for English.

It would help the reading to explain in the figure captions what the colored lines refer to, even if it is explained in the main text. In the main text, would it be possible to clarify what the maximum deviations shown by the colored vertical segments are: are they based on energy spectra measured by all the satellites, or only a subset? Would it also be possible to clarify the meaning of the following statement "on a logarithmic energy scale, the magnitudes of these segments do not depend on L shell"? Does it mean that the size of the segments changes a little bit with L, but not enough to be clearly seen when plotted with a logarithmic scale?

Section 3: this section is quite long, would it be possible to add subsection titles to help the reader? You may have a subsection on the protons in the (E,L) space that would start after line 170, one on the helium ions in (E,L) space that would start after line 259, one on the CNO ions in (E,L) space starting after line 287, and finally one on the

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protons and helium ions in the (L,B/B0) space starting after line 319.

Interactive comment on Ann. Geophys. Discuss., <https://doi.org/10.5194/angeo-2019-82>, 2019.

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