

Reply, angeo-2021-18, revision 2

Electromotive force in the solar wind  
Yasuhito Narita

Again, I thank the editor and the both referees for careful check and thoughtful comments.  
Reply comments are given here.

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Referee 1

- > The author has changed the article from a mini-review to a regular article.
- > More data, results and a table have been added which has enhanced the quality
- > of the paper on an important topic. I have only three comments which
- > in my view should be addressed before the paper is accepted, and few minor
- > editorial corrections. These can be easily incorporated in the manuscript
- > if the author thinks them to be relevant.
- >
- > Comments
- > 1) Since this is now a regular article, the article needs some more modification
- > to reflect this. For e.g. the abstract needs to change to reflect some of
- > the (new) observations mentioned in "summary and outlook".
- > As done in his previous article in Ann Geo, Narita & Voros (2018)
- > the author could include some more details on the methods,
- > for the completeness of this article and for the benefit of the readers.

Reply

The author consulted with the editors about the treatment of the manuscript (review or regular), and came to the conclusion that the manuscript type be kept as a review article. The reason of my earlier intension to change the article type into a regular one was that some journals do not accept any original data or new results in the review. I learned that AnGeo accepts that the review articles may contain some new results as far as the the new results do not dominate the article. So, the author finds the contents related to Narita and Voros (2018) are presented on an appropriate level (not dominating the manuscript).

\* page 1, line 2 (abstract), "A review of the electromotive force ..."

\* page 1, line 25 (section 1), "a review of ..."

- > 2) On page 9, the author says "note that the alpha effect test fails on one hand,
- > and the mean-field model can qualitatively reproduce the observed electromotive force."
- > This is an intriguing result. The scaling analysis that follows (eq. 22) says
- > that the alpha term should be almost as important as the beta term
- > (in fact, 4 times larger) which is as important as the gamma term.
- > Isn't this contradictory to the fact that the alpha effect test (section 3.3.1, fig 3)
- > fails, according to the author himself? The author could shed more light
- > on this aspect if he agrees with the contradiction. Perhaps the method
- > used for alpha-test needs a correction/modification or a caveat?

Reply

It is not a contradiction, but my writing was confusing and misleading.  
The text was corrected by emphasizing what the two results suggest as a lesson.

\* page 9, line 198-206 (section 3.3.3), The following text has been added.

"It is interesting to note that the test for the single alpha effect (i.e., proportionality of electromotive force solely to the mean magnetic field without the beta and the gamma effects) fails against the solar wind data after by Marsch and Tu (1992), yet that the test for the model with the three terms including the alpha, beta, and gamma terms successfully reproduces the measured electromotive force after Bourdin et al. (2018). The scaling analysis using Eq. (22) indicates that the alpha term should be almost as important as the beta term (in fact, 4 times larger) which is as important as the gamma term. Hence, the lesson is that the simplest model using only the alpha term is not sufficient, and that the magnetic diffusion and the cross helicity effect should be considered as well in the electromotive force composition. Under which conditions the alpha effect will dominate remains an observationally open question; perhaps there is a dependence on, e.g., fast or slow solar wind, quieter or more disturbed solar wind, association with transient events such as coronal mass ejections and corotating interaction regions."

> 3) Since this a regular article, the author should more clearly demarcate  
> what is new here with respect to Narita & Voros (2018). Adding some  
> text in the introduction and summary/outlook sections would address this.  
> One page 1, the author says "This article presents the emf studies in the  
> solar wind in view of the current in situ observations in the inner heliosphere  
> such as Parker Solar Probe (since 2018), Solar Orbiter (since 2020), and  
> BepiColombo's cruising to the Mercury orbit (since 2018)". However,  
> the data considered is not from any of these new missions, but from Helios,  
> same as in Narita & Voros (2018).

Reply

As replied in the point 1 above, the manuscript should remain for a review article, and the manuscript should serve as an appetizer for analyzing the data coming from the novel solar wind measurements. The analysis of Parker Solar Probe, Solar Orbiter, or BepiColombo cruise data will be presented elsewhere.

> Minor points  
> 1) Equation (5) occurs twice.

Reply

Corrected.

\* page 3, line 82. Equation number (6).

> 2) Typo/spelling errors in lines 16, 57, 101, 105, 168

Reply

Done.

- \* L16: page 1, line 16, "broadened"
- \* L57: page 3, line 58-59, "are available"
- \* L101: page 4, line 103, "the current helicity"
- \* L105: page 4, line 107, "persistently large"
- \* L168: page 8, line 170, "mean magnetic field"

> 3) Full stop missing at line 116 and few other places

Reply

Done.

- \* page 4, line 118, "fluctuation quantity."

> 4) Line 181 - "both the" instead of "the both"

Reply

Done.

- \* page 8, line 180, "Both the coefficients"
- \* page 8, line 183, "both the coefficients"

> 5) Lines 48-49, 62, 81 - "the second term the ...", "the third term the ..." ,  
 > etc needs to be changed to "the second term represents/is the ..." and so on.

Reply

- \* L48: page 2, line 49, "the second term represents"
- \* L49: page 2, line 49, "the third term represents"
- \* L63: page 3, line 63, "kinetic energy corresponds to"
- \* L81: page 3, line 83, "the coefficient  $\beta$  represents"

> Please check the draft for some additional typos that I may have missed.  
 > Nowadays there are many auto spell-check softwares available.

Reply

Done.

- \* page 8, line 180, "flow speed fluctuation"
- \* page 9, line 214, transport coefficients in Tab. 1

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Referee 2

- > The author has improved the paper based on the previous set of referee comments.
- > After addressing the following minor corrections, I would recommend publication.
- >
- > line 48: "frozen-in of the large-scale magnetic field" does not really make
- > sense in this context. This term describes the deformation of the large-scale
- > magnetic field by the large-scale flow.

Reply

I keep the sentence as is, and add the referee's suggestion in a bracket as follows.

\* page 2, line 48-49, "(strictly speaking, deformation of the large-scale magnetic field by the large-scale flow),"

- > line 58: "it is convenient to determine", did you mean "define" here?

Reply

Changed as follows.

\* page 3, line 59, "In general, in the observational studies, it is more practical to construct the covariance matrices..."

- > line 165: why not just include  $\mu_0$ , or normalize it to 1?

Reply

It is set to unity for simplicity.

\* page 8, line 167-168, "by setting the permeability of free space  $\mu_0$  to unity for simplicity

- > line 169: there is a typo on the LHS of equation (19) - it should be  $\mathbf{B} \cdot \mathbf{E}$  not  $\mathbf{B} \times \mathbf{E}$ .

Reply

Right, thank you!

\* page 8, line 171,  $\cdot$  on LHS in Eq. (20).

- > line 172: I would simplify "(density of) large-scale current helicity"
- > as "large-scale current helicity density".

Reply

Agreed.

page 8, line 174, "large-scale current helicity density"

- > line 227: "or the Reynolds stress tensors in magnetohydrodynamics".
- > I'm not sure why this statement is necessary - the Reynolds stress is
- > a fluid dynamical quantity and not directly related to MHD.

Reply

The concept of Reynolds stress is often introduced to the problems in magnetohydrodynamics as a generalized quantity, but to be safe with nomenclature, I changed the text as follows.

\* page 1, line 235, "(cf., the Reynolds stress tensors in fluid dynamics)."

> line 267: for consistency, perhaps change  $H_C$  in the main text to  $h_{crt}$ .

Reply

Yes!

\* page 8, line 173, " $h_{crt}$ " on RHS in Eq. (21)

\* page 8, line 175, " $h_{crt}$ " on LHS in Eq. (22)

> line 271: please specify which helicity you refer to.

Reply

It is the helicity in general sense.

\* page 13, line 283, "Note that the helicity in general (e.g., magnetic helicity density and current helicity)"

> line 302: typo: t4he.

Reply

Oh, ... thank you.

\* page 14, line 314, "the off-diagonal"

> Although the meaning of the text is clear, the written English could be  
> improved throughout the manuscript.

I ran the spelling checker.

\* page 8, line 180, "flow speed fluctuation"

\* page 9, line 214, transport coefficients in Tab. 1