Nonlin. Processes Geophys. Discuss.,
https://doi.org/10.5194/npg-2017-67-AC1, 2018

Nonlinear Processes in Geophysics
Discussions

Interactive comment on "Stratified Kelvin-Helmholtz turbulence of compressible shear flows" *by* Romit Maulik and Omer San

Romit Maulik and Omer San

osan@okstate.edu

Received and published: 22 February 2018

The authors would like to thank the Reviewer for their time to review our manuscript and to provide valuable comments and suggestions. We view their criticism positively, which we can address when we revise our manuscript. Here we would like to list our preliminary responses to each item raised by the Reviewer:

1-) As discussed in literature (e.g., see recent reviews by Zhou [1,2]), Rayleigh–Taylor and Richtmyer–Meshkov instabilities could introduce modified energy spectra and anisotropy, due to which we believe that some of the discussions there complement our observations in the present manuscript dedicated solely to the Kelvin-Helhmholtz instability (KHI) process. In our manuscript, we have computed two types of energy

spectra for both 2D and 3D KHI flows: (i) from regular velocity components, and (ii) from density weighted velocity components. We note that the way we formulate the problem at hand is special, since both 2D and 3D flows follow the same initial perturbation, which aids us in making an easy comparison of the difference between the 2D and 3D flows and their underlying physics. As highlighted in the manuscript, one of our main discussion points is the difference between density weighing in 2D and 3D flows. In 3D flows, the density spectrum follows the same scaling with the kinematic velocity spectrum, and therefore one may observe more or less similar scaling behavior when spectra are computed from density weighted velocities. In 2D flows, however, the density spectra follows a much shallower (flattened) scaling and this manifests in a substantial difference in the scaling between the spectra obtained from kinematic velocities and density weighted velocities. (a) We believe that the Reviewer's idea on using a Helmholtz decomposition is very useful, which can be done easily in our revision with the use of an FFT. We will follow the suggestion of the Reviewer and split the resolved velocity field into the solenoidal (divergence-free) and compressive (curl-free) components and compute their associated spectra. That will definitely strengthen our discussion. (b) Please see our discussion below in item 2 regarding the computation of the structure functions.

2-) As highlighted by the Reviewer, in the present manuscript, we have used the absolute value of velocity differences when we compute the structure functions. This arises from the definition of the structure function given by Boffetta and Ecke [3] (see their Eq. 4 which uses the absolute value). Aside from Boffetta and Ecke, the absolute value definition has also been used in many other studies (e.g., see [4], Eq. 21 in [5]). On the other hand, many researchers have used the definition without using the absolute value (e.g., [6,7]) and the choice of the computation of the structure function has been discussed by some researchers, for example see [8,9]. In [8], the difference has been identified using Fp (without using the absolute value) and Gp (with using the absolute value). Thanks to the Reviewer, we shall further compare these definitions (with and without the absolute values) when we present the third-order structure functions in our

revision. Indeed, this would be a nice analysis to see the differences in a KHI triggered 2D and 3D flow.

3-) We are in absolute agreement with the Reviewer that the k^{-3} scaling of the energy spectrum is associated with a direct-cascade of enstrophy in KBL theory. This was just a typographic error and we would like to thank the Reviewer for catching it. It will be corrected in our revision.

4-) We understand the Reviewer's concern here. Indeed, that was the reason why we included 4 different straight lines in our plots to give an accurate and fair comparison for each scaling. We believed that we can give the most accurate representation to the readers by that way. We thought that having one compensated line (as suggested by the Reviewer) could be useful but also mislead the reader since there is a slight variation in each case. In our revised manuscript, we can easily compute and present compensated spectra as well. Furthermore, another reason to put 4 systematically scaled lines in each figure (instead of compensating with only one scaling line) is to give a scaling representation beyond the inertial range (i.e., close to the dissipative scales). We noted that although the scaling for inertial range is different in 2D and 3D flows, we can see that the scaling merges to k^{-6} scaling towards the grid cut-off scale for both flows.

5-) The Reviewer is absolutely right. There was a typo in the first term, which should be written as (x+r). We will correct it. Thanks.

6-) This is another place we would like to thank the Reviewer. We had used, unintentionally, the wrong terminology and it should be a "spatial" averaging instead of "ensemble" averaging, and we will correct it when we revise our manuscript.

In conclusion, the authors would like to thank the reviewer again for their time and their valuable comments. Addressing these comments as explained above, we believe that the manuscript can be improved extensively in terms of concept, technical content and clarity of exposition.

Sincerely,

Omer San

References

[1] Zhou, Y. Rayleigh-Taylor and Richtmyer-Meshkov instability induced flow, turbulence, and mixing. I. Physics Reports 723-725, 1-136, 2017.

[2] Zhou, Y. Rayleigh-Taylor and Richtmyer-Meshkov instability induced flow, turbulence, and mixing. II. Physics Reports 723-725, 1-160, 2017.

[3] Boffetta, G. and Ecke, R. E. Two-dimensional turbulence. Annual Review of Fluid Mechanics 44, 427-451, 2012.

[4] Schmidt, W., Federrath, C. and Klessen, R. Is the scaling of supersonic turbulence universal? Physical Review Letters 101, 194505, 2008.

[5] Kritsuk, A.G., Norman, M. L., Padoan, P. and Wagner, R. The statistics of supersonic isothermal turbulence. The Astrophysical Journal 665, 416-431, 2007.

[6] Arenas, A. and Chorin, A. J. On the existence and scaling of structure functions in turbulence according to the data. Proceedings of the National Academy of Sciences of the USA 103, 4352-4355, 2006.

[7] Iyer, K.P., Sreenivasan, K. R. and Yeung, P.K. Reynolds number scaling of velocity increments in isotropic turbulence. Physical Review E 95, 021101, 2017.

[8] Arneodo, A., Baudet, C., Belin, F, Benzi, R., Castaing, B., Chabaud, B., Chavarria, R., Ciliberto, S., Camussi, R., and Chilla, F. Structure functions in turbulence, in various flow configurations, at Reynolds number between 30 and 5000, using extended self-similarity. Europhysics Letters 34, 411-416, 1996.

[9] van de Water, W. and Herweijer J.A. Anomalous scaling and anisotropy in turbulence. Physica B: Condensed Matter 228, 185-191, 1996.

Interactive comment on Nonlin. Processes Geophys. Discuss., https://doi.org/10.5194/npg-2017-67, 2018.