

This work was written as part of one of the author's official duties as an Employee of the United States Government and is therefore a work of the United States Government. In accordance with 17 U.S.C. 105, no copyright protection is available for such works under U.S. Law.

Public Domain Mark 1.0

<https://creativecommons.org/publicdomain/mark/1.0/>

Access to this work was provided by the University of Maryland, Baltimore County (UMBC) ScholarWorks@UMBC digital repository on the Maryland Shared Open Access (MD-SOAR) platform.

Please provide feedback

Please support the ScholarWorks@UMBC repository by emailing scholarworks-group@umbc.edu and telling us what having access to this work means to you and why it's important to you. Thank you.

Comments on “Alfvénic disturbances in the equatorial solar wind with a spiral magnetic field” by Yu-Qing Lou

Melvyn L. Goldstein

Laboratory for Extraterrestrial Physics, NASA Goddard Space Flight Center, Greenbelt, Maryland

The analysis by Lou [1994] attempts to compensate for known limitations of conventional WKB theory by adding modifications to include “an improved background interplanetary model and ... more complete Alfvénic perturbation solutions.” The analysis includes no dissipation and no nonlinear effects. There are many aspects of this work that warrant comment, but I shall limit myself to two questions: (1) Are the conclusions drawn by the author supported by his calculations? (2) What do the results reveal about the relevance of linear analyses to understanding how interplanetary parameters evolve with heliocentric distance? I shall try to illustrate that the answer to the first question is “no,” the conclusions are not supported by the calculations, and that the answer to the second question is that the most significant conclusion to be drawn from Lou [1994] is that the linear analysis is inconsistent with solar wind observations. Consequently, nonlinear effects cannot be ignored, even to lowest order, in attempting to account for the observed properties of magnetic field and velocity fluctuations in the heliosphere.

Lou [1994] draws four (tentative) conclusions. I shall concentrate on the first two: (1) “...the tendency of radial falloff for the magnitude of the normalized cross-helicity σ_c should be generic; its sign can be positive and negative at various radii as a result of interference.” (2) “...the Alfvén ratio r_a can attain scattered values (in our particular example its value is much < 1).” From Figures 1e and 1h it is seen that both σ_c and r_a vary widely for any particular choice of mode m (note that the azimuthal scales labeled by this index are essentially unobservable with a single spacecraft), both increasing and decreasing in ways not observed. In the “mixed case,” when several modes are superposed, the behavior of σ_c still differs from what is observed; not only does its magnitude oscillate from large to small values, but its sign changes as well. Lou [1994] claims that “...the overall decreasing tendency for the magnitude of σ_c is qualitatively in accord with observations....”, ignoring that the sign of σ_c is not observed to change except in the vicinity of gradients in velocity—an effect explicitly omitted in Lou’s analysis. The fact that the observations do not appear to ever show the oscillatory behavior of Figure 1 Lou attributes to using too few modes in his perturbation analysis without ever demonstrating that using more modes would, in fact, produce closure with observations. As for the second point, while I don’t know what is meant by “scattered values” of r_a , it is clear from Voyager data and simulations of velocity-shear induced turbulence that r_a does not become very much less than one [Roberts, 1992].

Any correspondence between the calculations in the work by Lou [1994] and observations is further obscured by the choice of initial conditions (Figure 1); none of which appears to approximate the high cross helicities seen in the inner heliosphere. Even the $m=-2$ case has σ_c at ~ 0.1 AU that is at most of order 0.5, for all other values of m , σ_c is much smaller. If none of the individual modes approximates observations at 0.3 AU, how can a superposition of many modes (not shown) do so?

The most troublesome aspect of the Lou’s paper, however, concerns what is not shown. To compare properly a linear analysis with solar wind observations, it is essential to find solar wind conditions which approximate the assumptions of the calculation. Because shear-induced nonlinearities will dominate the evolution of fluctuations, it is not surprising that Lou’s predictions differ so widely from the observations. However, there are solar wind data available from flows that have encountered neither stream shears nor corotating interaction regions and their associated shock waves. These data were described by Roberts *et al.* [1987, p. 12,031] as follows:

There is only one region in the Voyager data [near 8 AU] in Figure 7b (days 23–30) that shows consistent outward sense of correlation at all scales According to Whang and Burlaga [1985], this region had not interacted with any neighboring material.... Moreover, all other regions in the interval had undergone stream-stream interactions. The probably undisturbed region also shows outward propagation in the Helios data.

Although one might think that this citation was simply overlooked by Lou, the citations were pointed out to him during the refereeing of the manuscript. Lou has not acknowledged the questions raised by those data and their obvious applicability to his calculations in subsequent resubmissions of the paper. These data really illustrate the crux of my difficulties with Lou [1994] because for the interval cited by Roberts *et al.* [1987], σ_c is often above 0.8, so that any decrease in cross helicity has been very small.

As I noted in one of those referee reports: “It is rare in our field that a theory makes predictions that can be quantitatively tested, where the observed phenomena can be shown to satisfy the initial conditions of the theory, and where a clear observational answer can be obtained. That is the case with the present paper....” In my opinion, this issue should have been resolved before publication.

The crux of the issue is that Lou [1994] maintains that in the absence of strong nonlinearities such as velocity shear, the cross helicity will decrease substantially in the outer heliosphere due to the *linear* effects. That does not happen: when there is no velocity shear, there is little decrease in cross helicity. This and the other problems noted above indicate to me that this linear theory is totally inadequate for describing the properties and evolution of solar wind fluctuations.

This paper is not subject to U.S. copyright. Published in 1995 by the American Geophysical Union.

Paper number 95JA01212.

References

- Lou, Y.-Q., Alfvénic disturbances in the equatorial solar wind with a spiral magnetic field, *J. Geophys. Res.*, **99**, 14747, 1994.
- Roberts, D. A., M. L. Goldstein, L. W. Klein, and W. H. Matthaeus, Origin and evolution of fluctuations in the solar wind: Helios observations and Helios-Voyager comparisons, *J. Geophys. Res.*, **92**, 12023, 1987.
- Roberts, D. A., Observation and simulation of the radial evolution and stream structure of solar wind turbulence, in *Proceedings of Solar Wind 7, COSPAR Collq. Ser.*, vol. 3, edited by E. Marsch and R. Schwenn, Vol. p. 533, Pergamon, New York, 1992.
- Roberts, D. A., M. L. Goldstein, L. W. Klein, and W. H. Matthaeus, Origin and evolution of fluctuations in the solar wind: Helios observations and Helios-Voyager comparisons, *J. Geophys. Res.*, **92**, 12023, 1987.
- Whang, Y. C., and L. F. Burlaga, Evolution and interaction of interplanetary shocks, *J. Geophys. Res.*, **90**, 10765, 1985.

M. L. Goldstein, Laboratory for Extraterrestrial Physics, Code 692, NASA Goddard Space Flight Center, Greenbelt, MD 20771. (e-mail: u2mlg@ruach.gsfc.nasa.gov)

Received January 27, 1995; revised April 12 1995;
accepted April 13, 1995.)