Re: LZ13895
Probing neutrino hierarchy and chirality via wakes
by Hong-Ming Zhu, Ue-Li Pen, Xuelei Chen, et al.

Dear Mr. Zhu,

The above manuscript has been reviewed by our referees. While we cannot make a definite commitment, we will probably accept your paper for publication, provided you make changes that we judge to be in accordance with the appended comments (or other satisfactory responses are given).

With your resubmittal, please include a summary of changes made and a brief response to all recommendations and criticisms.

Yours sincerely,

Stanley G. Brown
Consulting Editor
Physical Review Letters
Email: prl@aps.org
http://journals.aps.org/prl/

IMPORTANT: Editorial "Review Changes"
http://journals.aps.org/prl/edannounce/PhysRevLett.111.180001

Second Report of Referee A -- LZ13895/Zhu

The authors have corrected the calculations as required, showing small changes in the final results. They say also to have checked their back of the envelope estimates against fully numerical integration, obtaining a signal only 15% smaller than what stated in the paper.

There are still some missing points in the text, as the value of the galaxy-bias adopted for the different surveys, the fact that all the galaxies are located at a fixed redshift (which is not a good approximation for very large surveys as LSST and Euclid), etc...

Since, at least for left-handed neutrinos, the authors find a signal orders of magnitude larger than future 21cm sensitivities, I do not think more precise calculations would alter the main conclusions of the manuscript. However, the authors should add a few words about the galaxy bias adopted in the paper, and provide some explanation for their choice to locate all the galaxies at a fixed redshift, instead of using the correct galaxy distribution of Euclid and LSST.

Given the provided checks, and the quite original idea, I suggest publication in PRL, once the authors have made the small additions mentioned above.

Report of Referee B -- LZ13895/Zhu

The paper proposes a new way of measuring the neutrino mass, using a distortion of the weak lensing shear field by neutrino wakes around halos. However, the effect is extremely small, and would always be smaller than the effect of the neutrino mass on the power spectrum. The euclid+LSST constraints (already futuristic) only constrain the mass to a level already ruled out by current galaxy clustering surveys. Given this, the paper in my view clearly fails the notability requirement for PRL and thus should not be accepted as a Letter.

I also share the concerns of the previous referee that the calculations, essentially order of magnitude estimates, presented here are still overly simplistic and overly generous, and reject it also for that reason.

Overall I feel that when the below points are addressed, it will be clear that the effect is far too small to ever observe, in which case to be accepted the paper should be resubmitted to PRD making this conclusion clear in the abstract. I may be wrong about this, but I would ask the authors to perform the calculation with some care. Effects this small are easily swamped.

Specifically:

1. N-body simulations run by Inman et al. 2015 found that the nonlinear effect is substantially smaller than the linear theory effect assumed here. Part of this is due to the assumption of a static halo mass to estimate the effect of neutrino wakes. You should use the more correct non-linear effect, especially since you are the same authors on both papers.

2. It is not clear to me that your assertion that nothing else creates the dipole moment due to neutrino wakes is true. For example, it seems

to me AGN jets could easily induce a local dipole. As the neutrino wake effect is very small, even a small effect of AGN can swamp the neutrino wake signal.

3. In the simple mode-counting arguments employed to estimate observability, particularly for the 21 cm experiment, the error on kappa is dominated by the large number of small-scale modes. However, the neutrino wake effect occurs only on large scales, and goes to zero for k > 1, so only these modes should be counted when estimating errors. This would greatly diminish the power of the 21 cm experiment at least.

4. The 21 cm experiment as described in the given reference is futuristic to the point of total infeasibility. It is also only vaguely sketched, and I do not feel you have done enough work to demonstrate its potential to measure neutrino wakes. For example, the calculation done in the paper is for large halos at z=0.3. If you wish to include 21 cm constraints, you should perform a calculation of the neutrino wake effect for the smaller and higher redshift halos which are measured by a dark ages 21 cm experiment.

5. Finally, as a small point, rather than using non-standard terms such as ‘quasi-degenerate’ in the abstract, it would be better to frame the paper as quantitative potential constraints on physical variables, like the neutrino mass, or the mass splitting.

Report of Referee C -- LZ13895/Zhu

This paper discusses an interesting, original idea on a potential probe to the neutrino sector of the dark matter, by comparing the mass density field that is inferred from the large-scale distribution of galaxies and from weak gravitational lensing, and focusing on the phenomenon of the wake produced by dark matter halos on the distribution of neutrinos.

In my opinion the paper should be accepted for publication in Physical Review Letters. This new idea can clearly give rise to new developments in the field of large-scale structure. Even though the idea has not been exhaustively checked with numerical simulations, and the effect is very small and difficult to detect with currently planned surveys, I think this is not a reason to prefer publication in Phys. Rev. D. The letters should precisely highlight new ideas that may potentially introduce new elements of discussion in their research field. The authors have reasonably answered the comments of the previous referees.

I would also like to give the following comment to the authors: it is assumed in the paper that the non-linear effect that depends on the presence of neutrinos with a certain velocity dispersion as a dark matter component is described as wakes that can be modeled as if they were created by halos of fixed mass M. This is not clear to me, actually the wakes are produced by the entire large-scale structure, not just halos, and the halos in any case do not have fixed mass but they are continuously growing. In the end, the thing that is important is that one uses the galaxy distribution to predict a large-scale velocity field, and from this, to predict a difference between the density field of cold dark matter and that of neutrinos, as a function of the neutrino velocity dispersion. Weak lensing is then used to test if the neutrino component is there, and to measure its contribution to the density. The question is to what extent one can measure the small difference due to neutrinos. It is not clear if this difference is adequately modeled by considering the abundance of halos of mass M; perhaps the real overall effect might be larger than this simple halo model predicts. This can only be studied in a much more complete work, but I think the authors may consider saying something about this.