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Interactive comment on "Mirror mode physics: Amplitude limit" *by* Rudolf A. Treumann and Wolfgang Baumjohann

Anonymous Referee #2

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The manuscript discusses a possible mechanism to support formation of large amplitude mirror mode or magnetic bottle elongated along the magnetic field. Generation of electron pairs consisting of two electrons is assumed, and necessary conditions for their existence are discussed based on electrostatic potentials and interaction with ion sound waves. An electron pair is assumed to from a coherent gyration current at which reduces the magnetic field inside the mirror bottle. The idea sounds interesting, but it is not convincing to assume the formation of the electron pairs based on the theoretical explanation presented in the manuscript as commented below.

1. First of all, it is not clear why we need to study electron dynamics for the mirror mode which can be supported by ion dynamics only. Temperature anisotropy of thermal ions and its thermalization in the nonlinear stage may well be good

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enough to support the large amplitude mirror modes in the magnetosheath. For example, a hybrid code simulation [Shoji et al., 2012], where electrons are treated as a fluid, shows formation of large amplitude mirror mode waves. These mirror mode structures are very dynamic in the time scale of hundreds of the ion cyclotron period repeating nonlinear coalescence of magnetic structures initially formed by the linear mirror-mode instability driven by temperature anisotropy of the thermal ions. In such evolution of the mirror mode magnetic fields controlled by ion dynamics, assumption of formation of electron pairs in an ultimate state of quasi-linear equilibrium is not realistic.

2. In considering electron pair formation, the authors only assume electrostatic forces and gyro-averaged mirror force. However, there should be some Lorentz force due to the perpendicular velocities and transverse wave magnetic fields such as whistler mode waves. In addition to resonances with the ion sound waves, resonances with other eigenmodes in the magnetic bottle (whistler mode wave and Langmuir waves) should be considered.

3. Description of the coherent gyration current J_{pair} is insufficient and difficult to understand. What is the relation of gyro-phases of the two electrons forming the pair? Can they be stable? Generally, a nongyrotropic distribution of electrons is strongly unstable generating electromagnetic waves from the transverse current.

4. Analogy with the Meissner effect in superconducting metal is used all through the discussion. More quantitative confirmation by simulations is necessary to make the readers convinced with the proposed mirror mode physics.

Reference

M. Shoji Y. Omura, and L.-C. Lee, Multidimensional nonlinear mirror-mode structures in the Earth's magnetosheath, J. Geophys. Res., 117, doi:10.1029/2011JA017420, 2012.

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