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

Anonymous Referee #4

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This is a very interesting paper presenting an unorthodox view on the nonlinear state of the mirror instability. The authors build on the previous work of studying the attractive potential of electrons in plasma due to interaction with plasma waves. They propose that under special conditions, when in resonance with ion acoustic waves, the Debye shielding of a point charge can result in a positive effective potential and thus attract other electrons. In an analogy with the theory of superconductivity, the authors propose that the electrons can form gyrating pairs which in turn exhibit a diamagnetic effect due to their magnetic moment. This effect is proposed to reduce the magnetic field inside mirror structure, being responsible for the observed shape and amplitude of mirror modes.

While I think that the paper is an interesting contribution to nonlinear mirror mode

physics and as such is definitely worth publishing, there are some crucial points which are not clear to me and perhaps should be addressed in a revision.

1) Perhaps I do not understand the reasoning properly, but from section 5.1 it seems that the centers of mass of the electrons continue in their bouncing inside the magnetic mirror. On the other hand, on lines 505-507, it is said that the pairs drop out of the bouncing motion and are locked in their position. This is not clear to me. How does it follow from section 5.1 ? Could you pleaswe clarify ?

2) While I understand how the electron pair can be formed, it is unclear how they can be sustained for a longer time. The attractive potential can only be present while in resonance with the wave. Bouncing electron pairs would get out of resonance as soon as they move away from the vicinity of point s_m. Assuming that the electrons are indeed locked in the appropriate location (see point 1 above), doesn't maintaining the attractive potential require some pre-existing ion-sound wave which the electrons are in phase with ? I would expect the phases of the thermal ion sound waves to fluctuate and get out of phase quickly.

Is the jittering motion of the electron pair compatible with being in resonance with the waves ?

3) My main comment is to the discussion of magnetic susceptibility in section 5.3. I do not understand how the magnetic moments of the gyrating electron pairs differ from the magnetic moments of ordinary trapped gyrating electrons. The gyrating pairs certainly contribute some magnetic moment, but so do single gyrating electrons with a similar perpendicular velocity. The authors make references to coherent motion, but little justification or explanation is provided, apart from vague a reference to the theory of superconductivity.

Minor points:

- line 61: "It are ..." sounds wrong - line 450: there is probably a word missing after

“magnetic”. The sentence is thus unclear. - equation 34: the variable y should be defined.

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