Ann. Geophys. Discuss.,
https://doi.org/10.5194/angeo-2019-28-RC1, 2019

Annales Geophysicae Discussions

Interactive comment on "The linear growth rate of Rayleigh–Taylor instability in ionospheric F layer" *by* Kangkang Liu

Anonymous Referee #1

Received and published: 26 March 2019

This study challenges the standard ionospheric electrodynamics and proposes the new definition of the linear growth rate of the Rayleigh-Taylor instability (RTI) in the equatorial ionosphere. The commonly used linear growth rate of RTI in the equatorial ionosphere is written as $g/(L\nu_{in})$. Author noticed the problem that the growth rate is going to be infinity when ν_{in} goes to zero, whereas the growth rate of RTI in the collision-less plasma should have finite value. The obtained result seems to connect the theoretical gap between collisional and collision-less plasma naturally and build a seamless instability theory from the ionosphere to magnetosphere. However, the assumption to derive the old expression is usually valid in the ionosphere, and the difference between the old and new growth rate is negligible. Therefore, the title and the conclusion of the paper are misleading. I recommend that author should not

focus on the equatorial ionospheric F layer, but on filling the theoretical gap between collisional and collision-less plasma, which may be an interesting topic.

Author mentioned in page 2 that "when current continuity equation applied, there will be no perturbation electric field due to charge accumulation." It is not correct description. From the Gauss law, $\partial\rho/\partial t + \nabla \cdot J = 0$ is derived. It means $\partial\rho/\partial t = 0$ when the current continuity is satisfied. It does not say $\rho = 0$. Due to very small charge accumulation, electrostatic polarization field is set up. The charge accumulation is so small that the current continuity equation is applied in the electrodynamics in the ionosphere. Authors should estimate quantitatively the amount of charge accumulation produced during the Rayleigh-Taylor instability process. See Chapter 2.3 of Kelley (2009). Very small charge accumulation could produce large electric field. I think the new point in this paper is the inclusion of $\partial E/\partial t$ term in Equation (15). It is very small in the ionosphere, and is going to be important when the ratio of Alfvén speed to the speed of light becomes large.

In order to compare the old and new growth rate intuitively, the new growth rate should be written in the following way.

$$\begin{aligned}\gamma &= \frac{\left(\sqrt{\frac{g}{L}+\frac{\nu_{in}^2}{4}}-\frac{\nu_{in}}{2}\right)\left(\sqrt{\frac{g}{L}+\frac{\nu_{in}^2}{4}}+\frac{\nu_{in}}{2}\right)}{\left(\sqrt{\frac{g}{L}+\frac{\nu_{in}^2}{4}}+\frac{\nu_{in}}{2}\right)} \\ &= \frac{g}{L}\frac{1}{\sqrt{\frac{g}{L}+\frac{\nu_{in}^2}{4}}+\frac{\nu_{in}}{2}} = \frac{g}{L\nu_{in}}\frac{1}{\sqrt{\frac{g}{L\nu_{in}^2}+\frac{1}{4}}+\frac{1}{2}}\end{aligned}$$

Then it can be easier to understand when the new terms become significant. When ν_{in}^2

is significantly larger than g/L, which is usually satisfied in the ionosphere, the growth rate turns to be the traditional expression $g/(L\nu_{in})$. In Figures 2 and 3, the estimated growth rate is plotted with regard to the normalized parameters. What altitude do these parameters correspond to? If the new growth rate should be applied in the ionosphere, substitute the typical values of collision frequency and Alfvén speed of the ionosphere, and show how the growth rate is modified.

Interactive comment on Ann. Geophys. Discuss., https://doi.org/10.5194/angeo-2019-28, 2019.