Marginal threshold condition for ordinary mode instability for Non-extesnsive anisotropic distribution

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The distribution function has different forms in the different region of space plasmas. These change in the distribution significantly affects the dispersion properties of the waves especially their free energy source (if exist) can make the wave unstable under certain conditions. These instablities as an effect of free energy source is a great deal of interest in space plasma community to their application to different solar wind problems e.g., particle acceleration etc.

The non-extensive distributions have received renewed attention due to the better agreement with the space plasma observations as compared to the Maxwellian distribution.The temperature anisotropy is one of the available free energy sources in the space plasma in particular to the solar wind. The temperature anisotropy makes the wave unstable based depending upon whether the anisotropy ratio ($A = Tx/Tz$) is either greater ($A > 1$) or smaller ($A < 1$) than one.

The Bale-diagram [1] obtained by the solar wind data is clear indication of this relation showing four different region of anisotropy-plasma beta space. These different regions are bounded by the instabilities. Davidson and Wu [2] first discussed the electromagnetic ordinary (O) mode instability can become unstable for anisotropy ratio greater than one and high plasma beta. Ibscher et al. [3] revisited the work [2] and obtained the marginal and threshold conditions of the o-mode instability for electrons for the bi-Maxwellian distribution. Ref. [4] extended the to the solar wind proton anisotropy and related to the Bale-diagram. The exact numerical analysis contrary to the above theoretical results is predicted by Hadi et al. [5] and clearly proved that the lower left bound of Bale-diagram is bounded by the O-mode instability in the counter-streaming plasmas.

In this work, the marginal instability threshold condition of ordinary mode(O-mode) is obtained using the exact numerical analysis to explain the Bale-diagram obtained from the solar wind data at 1 AU for Non-extesnive distribution. It is shown that the lower bound of the Bale-diagram is bounded by the O-mode instability. The effects of non-extensivity parameter q on the marginal stability curve are also highlighted to better model the Bale-diagram through Non-extesivity index q as compared to the usual Maxwellian distribution.

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