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Ion kinetic equilibrium for magnetopause-like tangential layers

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Searching for kinetic (Vlasov) equilibria for asymmetric tangential current layers like the magnetopause is a longstanding problem which has never received complete answers. Beyond the general and theoretical interest of finding such equilibria, the question is also of pivotal importance for initializing PIC or hybrid numerical simulations, in particular in the context of reconnection studies. When one just uses, as usual, an approximate equilibrium which involves Maxwellian distributions whose moments respect the fluid equilibrium, one obtains a plasma state which is not a kinetic equilibrium, and this always results in escaping waves and oscillations of the layer. Studying the stability of such a system, with respect for instance to tearing instability, is therefore a perilous operation since it amounts to studying the stability of a non equilibrium state.
The usual research method of Vlasov equilibrium supposes that both electron and ion distributions have the same known analytical form and then calculates the consistent magnetic fields via Maxwell's equations. This method leads in particular to the famous model of "Harris current sheet" (where the current is simply carried by particles drifting with a constant velocity, which implies that the density must decrease symmetrically down to zero on both sides). On the contrary, our method imposes first the magnetic field profile and calculate afterward an ion distribution function compatible with this magnetic field profile (the same can be done for electrons but the present work is presented in the frame of hybrid modeling). The analytical form of the ion distribution is still imposed, but given with as many free parameters as necessary to make the result respect the asymptotic values for density and pressure and grant the distribution continuity at the point $B = 0$.
The first theoretical results obtained by this method will be presented, together with preliminary results of their implementation in a hybrid code.