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Nonlinear dependence of anomalous ion-acoustic resistivity on electron drift velocity

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Collisionless magnetic reconnection requires the violation of ideal MHD by various kinetic-scale effects. Recent research has highlighted the potential importance of wave-particle interactions by showing that Vlasov simulations of unstable ion-acoustic waves predict an anomalous resistivity that can be significantly higher in the nonlinear regime than the quasi-linear estimate. We investigate the dependence on the initial electron drift velocity of the current driven ion-acoustic instability and its resulting anomalous resistivity. We examine the properties of statistical ensembles of 10 Vlasov simulations with real mass ratio for a range of drift velocities and for electron to ion temperature ratios 0.9, 1 and 2, relevant to both solar and magnetospheric physics. We show that the ion-acoustic anomalous resistivity depends nonlinearly on the electron drift velocity for the low temperature ratios examined, in contrast to the linear dependence predicted by theory and commonly assumed in models of magnetic reconnection. Specifically we find that a) anomalous resistivity is a power law function of the electron drift velocity (v_{de}/θ_e^m), approximately with exponent $\beta \sim 8-10$, and b) anomalous resistivity is a power law function of the normalized drift velocity $(v_{de}-v_{crit})/\theta_e^m$, approximately with exponent $\alpha \sim 2.5-6$. An anomalous resistivity model consistent with our results could be important for simulations of magnetic reconnection in astrophysical plasmas.

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