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A one-dimensional Vlasov-Maxwell equilibrium for the force-free Harris sheet

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The first non-linear force-free Vlasov-Maxwell equilibrium is presented. One component of the equilibrium magnetic field has the same spatial structure as the Harris sheet, but whereas the Harris sheet is kept in force balance by pressure gradients, in the force-free solution presented here force balance is kept by magnetic shear. Magnetic pressure, plasma pressure and plasma density are constant. The method used to find the equilibrium is based on the analogy of the one-dimensional Vlasov-Maxwell equilibrium problem to the motion of a pseudo-particle in a two-dimensional conservative potential. This potential is equivalent to one of the diagonal components of the plasma pressure tensor. After finding the appropriate functional form for this pressure tensor component, the corresponding distribution functions can be found using a Fourier transform method. The force-free solution can be generalized to a complete family of equilibria that describe the transition between the purely pressure-balanced Harris sheet to the force-free Harris sheet.