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On the role of the parallel proton fire hose instability in the expanding solar wind

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Proton fire hose instabilities can take place in a magnetized plasma with proton temperature anisotropy $T_{\|p} > T_{\perp p}$; these conditions naturally develop in the expanding solar wind. We present results from 1D Hybrid Expanding Box (HEB) simulations where propagation strictly parallel to the magnetic field is considered. We found that the parallel proton fire hose instability is able to counteract the growth of the anisotropy due to the adiabatic expansion. The saturation level of the instability is in good agreement with the linear theory, 1D standard hybrid simulations and with constraints inferred from *in situ* measurements. We also investigated the role of the wave-particle interaction on shaping the proton distribution functions. Using the expanding hybrid simulations we correct the proton parallel and perpendicular plasma betas predicted by a fully kinetic numerical solar wind model which includes coulomb collisions. The resulting proton properties are constrained in a range close to the observations.