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Oblique firehose instability in hot collisionless plasmas – interplay between protons and electrons

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We solve the linearized kinetic Vlasov-Maxwell dispersion relation for oblique wave propagation in a homogeneous highly anisotropic hot electron-proton plasma. We assume bi-Maxwellian velocity distributions for both species, charge neutrality and current conservation, and consider no differential streaming between the ions and the electrons. We calculate the growth rate of the parallel and oblique proton firehose instabilities for various angles of wave propagation and varios electron plasma properties. We study the transition from stable to unstable scales with increasing electron temperature and temperature anisotropies. We find that for highly anisotropic hot plasma both the oscillatory parallel and the aperiodic oblique proton firehose branches may easily couple to the parallel and oblique electron firehose branches. In other words our work demonstrates the interplay between the proton and electron firehose instabilities, whose scales become fully mixed in hot collisionless plasma when the protons and the electrons are simultaneously anisotropic. In the case of parallel wave propagation both left and right-hand polarized waves are simultaneously excited. As we increase the angle of propagation the electron firehose starts to dominate with excitation of large-amplitude aperiodic fluctuations over a large range of wave-numbers, starting at the protons scales and extending up to the smaller electron scales. Whereas the maximum growth rate of the parallel proton firehose branch remains always at the proton scales, the maximum growth rate for the oblique proton firehose extends down to the electron scales. The observed electron-proton scale mixing can have significant implications for the observed plasma properties and instability thresholds in hot colissionless solar wind streams.