Geophysical Research Abstracts
Vol. 20, EGU2018-10163, 2018
EGU General Assembly 2018

Evolution of firehose-unstable electron and proton velocity distributions in a 2.5D PIC simulation

Philippe-A. Bourdin (1) and Yana Maneva (2)

(1) Space Research Institute, Graz, Austria (philippe.bourdin@oeaw.ac.at), (2) Centre for Mathematical Plasma Astrophysics, KU Leuven, Belgium (yana.maneva@kuleuven.be)

In situ observations in the collisionless solar wind indicate a strong presence of various non-thermal features such as highly anisotropic particle distribution functions with field-aligned beams, supra-thermal populations, and different temperatures along and across the ambient magnetic field. The electron velocity distribution consists of a core, a supra-thermal halo, as well as a prominent strahl that carries most of the heat flux in the solar wind. Due to the extended strahl, the overall electron distribution function has a larger temperature component in the field-aligned parallel direction and a lower temperature in the perpendicular direction. This makes the electrons prone to the firehose instability. On the other hand, the ions have a larger perpendicular temperature close to the Sun. Yet, as the solar wind expands into the heliosphere, the ions also cross the instability threshold and eventually become firehose-unstable. In this work we focus on the extreme case of highly anisotropic electrons and protons in the heliospheric solar wind and follow their nonlinear evolution. A linear instability analysis for these parameters suggests a strong interplay between the proton and the electron firehose with strongest growth for the oblique aperiodic modes. In this study we perform a 2.5D particle-in-cell simulation to test the theoretical predictions and investigate the nonlinear evolution of the system. With a large number of computational particles we achieve the statistical significance to deduce the temporal evolution of the velocity distribution functions. We find a structure formation in the electric field with a characteristic spatial scale that is connected to oscillating electrons at a characteristic frequency.