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Generation of suprathermal alpha beams by wave-particle interactions and localized small-scale current sheets in a drifting proton-alpha plasma

Yana Maneva and Stefaan Poedts

KU Leuven, CmPA, Celestijnenlaan 200B, 3001 Heverlee, Belgium (yana.maneva@wis.kuleuven.be)

In-situ measurements by various spacecraft in the collisionless solar wind indicate the ubiquitous presence of suprathermal populations once the particles small scale dynamics is resolved. Furthermore minor ions such as alpha particles are frequently observed to move faster than the lighter protons, creating a relative drift between the two species. These non-thermal features are often accompanied by the presence of electromagnetic waves, such as whistlers or kinetic Alfvén waves for example, but the exact wave-particle correlation is hard to detect by most of the spacecraft due to the different resolution of the fields and the particles instruments on board. On the other hand the solar wind is highly turbulent and the nonlinear interactions there lead to the formations of anisotropic broad-band wave spectra as well as current sheets. Here we present the results from a 2.5D hybrid simulation study with a focus on the generation of suprathermal populations of protons and alpha particles via wave-particle interactions and localized particle acceleration at small scale current sheets. The ion species in the simulations can exhibit beam formations caused by the waves or be accelerated at localized current sheets, where the alpha particles get preferentially energized. The current sheets are self-consistently generated during the nonlinear evolution of a decaying weak turbulence broad-band spectra and co-exist with the input of highly oblique kinetic Alfvén waves. The initial velocity distributions are drifting Maxwellians, which are locally deformed and develop suprathermal features. While the ion heating by parallel and quasi-parallel waves appears more uniform, the highly oblique waves are related to small scale current sheets, which result in localized acceleration and inhomogeneous velocity distribution functions.