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Fully kinetic simulations of the near-Sun solar wind plasma: turbulence, reconnection, and particle heating

Luca Franci[1], Emanuele Papini[2], Alfredo Micera[3], Lorenzo Matteini[4], Julia Stawarz[4], Giovanni Lapenta[5], David Burgess[1], Petr Hellinger[6], Simone Landi[7], Andrea Verdini[7], and Victor Montagud-Camps[6]

[1]School of Physical and Chemical Sciences, Queen Mary University of London, London, United Kingdom
[2]Istituto di Astrofisica e Planetologia Spaziali, INAF, Rome, Italy
[3]Solar-Terrestrial Centre of Excellence–SIDC, Royal Observatory of Belgium, Brussels, Belgium
[4]Department of Physics, Imperial College London, London, United Kingdom
[5]Centre for Mathematical Plasma Astrophysics, KU Leuven, Leuven, Belgium
[6]Astronomical Institute, CAS, Prague, Czech Republic
[7]Dipartimento di Fisica e Astronomia, Università degli Studi di Firenze, Florence, Italy

We model the development of plasma turbulence in the near-Sun solar wind with high-resolution fully-kinetic particle-in-cell (PIC) simulations, initialised with plasma conditions measured by Parker Solar Probe during its first solar encounter (ion and electron plasma beta ≤ 1 and a large amplitude of the turbulent fluctuations). The power spectra of the plasma and electromagnetic fluctuations are characterized by multiple power-law intervals, with a transition and a considerable steepening in correspondence of the electron scales. In the same range of scales, the kurtosis of the magnetic fluctuations is observed to further increase, hinting at a higher level of intermittency. We observe a number of electron-only reconnection events, which are responsible for an increase of the electron temperature in the direction parallel to the ambient field. The total electron temperature, however, exhibits only a small increase due to the cooling of electrons in the perpendicular direction, leading to a strong temperature anisotropy. We also analyse the power spectra of the different terms of the electric field in the generalised Ohm's law, their linear and nonlinear components, and their alignment, to get a deeper insight on the nature of the turbulent cascade. Finally, we compare our results with those from hybrid simulations with the same parameters, as well as with spacecraft observations.