Numerical simulation support to the ESA/THOR mission

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THOR is a spacecraft concept currently undergoing study phase as a candidate for ESA medium-size mission M4. THOR has been designed to solve the longstanding physical problem of energy dissipation and particle energization in turbulent plasmas and will provide high resolution measurements of electromagnetic fields and particle distribution functions with unprecedented resolution, with the aim of exploring the so-called kinetic scales. We present the numerical simulation framework which is acting as a support for the development of the THOR mission. The THOR team includes many scientists developing and running different simulation codes (Eulerian-Vlasov, Particle-In-Cell, Gyrokinetics, Two-fluid, MHD, etc.), addressing the physics of plasma turbulence, shocks, magnetic reconnection and so on. Here, we focus on the numerical results of the hybrid Vlasov-Maxwell code which integrates the Vlasov equation for the ion species, while the electrons are considered as a fluid. In the turbulent regime, at ion scales, kinetic effects manifest through a deformation of the particle velocity distribution (VD). These patterns of non-Maxwellian features are concentrated in space nearby regions of strong magnetic activity: the VDs are modulated by the magnetic topology, can elongate along or across the local magnetic field and show the generation of beams. The HVM simulations indicate that the details of the VDs are crucial for the understanding of turbulent heating at kinetic scales. The numerical results well agree with recent data analyses, based on direct observations from spacecraft in near-Earth space, motivating a strong synergy between simulations and in situ spacecraft data, but also point at the limitations of the presently available measurements. In particular, we show how an essential part of the information on the VD is being lost when measurements lack a certain level of precision, and thus we impose important constraints on the future particle measurements by THOR.