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On defining the distribution function in a kinetic plasma

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Mathematically the velocity distribution functions (VDFs) in kinetic theory are defined in the continuum limit [1]. However, in reality the VDFs are computed from particle measurements made by particle instruments such as Faraday cups or Electrostatic Analysers [2]. A natural question arises: How big a sample should be taken to compute the VDF in a plasma? A large volume would include bulk motions of plasma into the internal degrees of freedom, for example resulting in apparent anistropy [3]. On the other hand, a tiny volume might not have enough particles to get a reasonable probabilistic representation. Here we address this question using particle data from fully kinetic simulations. We compute particle distribution functions using the particle data from a fully kinetic turbulence simulation and vary the scale of integration to compute the VDF. We discuss the effects that larger integration volumes can have on the distribution function. The non-Maxwellianity of the distribution function is studied as a particular example of quantities affected by the integration scale issue.

References

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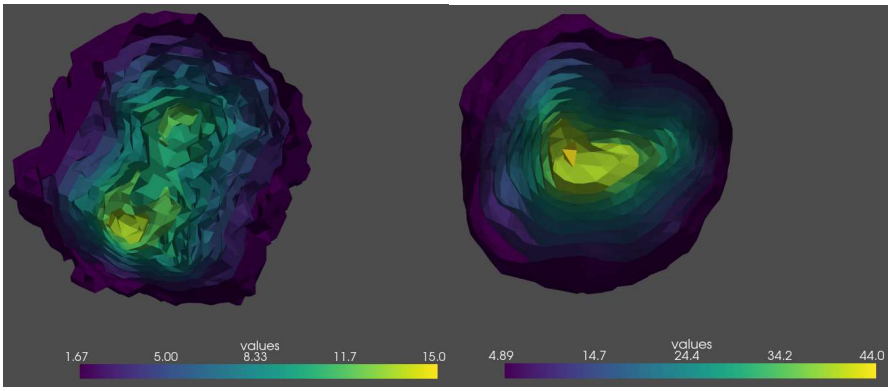

Figure: Electron (left) and ion (right) distribution functions from a highly non-Maxwellian region of a 2.5D fully kinetic PIC simulation of turbulence. Multiple non-Maxwellian features are visible in both distribution functions including the presence of field aligned beams.