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Plasma relations from kinetic modelling of special-relativistic turbulence

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The small scales properties of astrophysical plasmas near accreting compact objects are still poorly understood. For instance, in modern general-relativistic magnetohydrodynamic simulations, the relation between the temperature of electrons and protons is prescribed in terms of simplified phenomenological models where the electron temperature is related to the proton temperature in terms of the ratio between the plasma and magnetic pressures (beta). We present a very comprehensive campaign of 2D kinetic Particle-In-Cell (PIC) simulations of special-relativistic turbulence to investigate systematically the microphysical properties of the plasma in the relativistic regime. Using a realistic mass ratio between particle species, we analyze how the index of the electron energy distributions, the efficiency of nonthermal particle production, and the temperature ratio vary over a wide range of values of plasma beta and magnetization. For each of these quantities, we provide two-dimensional fitting functions that describe their behavior in the relevant space of parameters, thus connecting the microphysical properties of the plasma to the macroscopic ones. Our results can find application in a wide range of astrophysical scenarios, including the accretion and the jet emission onto supermassive black holes, such as M87 and Sgr A.

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