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An efficient treatment of the full Coulomb collision operator with applications

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A formulation of full Coulomb (or Landau) collision operator is provided that allows for an efficient numerical implementation, both in unmagnetized and magnetized plasmas [1]. The method is based on projecting the Boltzmann equations and the collision operator onto a Hermite-Laguerre velocity-space polynomial basis, obtaining a moment-hierarchy. This approach is implemented in a numerical simulation code and studies of systems of increasing complexity are being carried out, shedding light on the importance of retaining the full Coulomb collision operator, with respect to widely used simplified operators. First, the dynamics of electron-plasma waves is described at arbitrary collisionality for the first time by considering the full Coulomb collision operator [2]. In particular, a purely damped entropy mode, characteristic of a plasma where pitch-angle scattering effects are dominant with respect to collisionless effects, is shown to emerge numerically, and its dispersion relation is analytically derived. This mode is absent when simplified collision operators are used, and like-particle collisions strongly influence its damping rate. Second, the linear properties of drift-waves are investigated, which allows for the comparison of the Coulomb collision operator to collision operators used in state-of-the-art turbulence simulation codes [3]. Established collisional and collisionless limits are retrieved and an analysis on both the growth rate and eigenmode spectrum shows the need for retaining the Coulomb collision operator, specially at the intermediate levels of collisionality relevant for present and future magnetic confinement fusion devices. ([1] R. Jorge et al, Journal of Plasma Physics 83, 6 (2017); [2] R. Jorge et. al, Journal of Plasma Physics 85, 2 (2019); [3] R. Jorge et al, Physical Review Letters 121, 16 (2018))