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Influence of High Magnetic Field on Coulomb Collision and Plasma Transport

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Recently, the high magnetic field tokamaks have attracted wide attention. It is extremely urgent to investigate the influence of high magnetic field on Coulomb collision and plasma transport. The high magnetic field will significantly affect the collision and related processes when the Larmor radius is smaller than Debye length which is the effective space size for Coulomb collision.
For typical tokamak, the effect of high magnetic field may be only significant in edge plasma where Debye length is much larger than Larmor radius. For EAST tokamak, Debye radius is about 3 times of Larmor radius in edge plasma where if the plasma density is 10^13 per cm^3 and the toroidal magnetic field is 3T.
However, for high magnetic tokamak, the effect of high magnetic field may be significant both in edge and core plasma since Debye length is much larger than Larmor radius in whole plasma. For FIRE tokamak with toroidal magnetic field 10T, Debye radius is 4.9 times of Larmor radius in edge plasma where if the density is 4*10^13 per cm^3, meanwhile Debye radius is about 1.5 times of Larmor radius in core plasma where if density is 4*10^14 per cm^3.
The magnetized Fokker-Planck collision term is derived by using the binary collision model. The magnetized Fokker-Planck coefficients are calculated explicitly. This full magnetized Fokker-Planck collision term is also manipulated into the Landau collision term, which is shown to be identical to that obtained from the BBGKY approach when the wave contribution is neglected.[1]
The full magnetized Balescu-Lenard-Guernsey collision term is derived by employing the Fokker-Planck approach based on the wave theory. Manipulating the magnetized Fokker-Planck collision term into the Landau form, the magnetized Balescu-Lenard-Guernsey collision term is obtained, which is identical to the results derived by using the BBGKY hierarchy of equations and the quasilinear method.[2]
The magnetized Fokker-Planck coefficients have been simplified to investigate the influence of magnetic field on relaxation and transport phenomena. The cross-field transport has been investigated for the reflection of electrons after collision along the magnetic field. The friction and diffusion coefficients have been derived. It is found that the friction and diffusion coefficients are three times comparing with the cases of zero magnetic field when electron velocity is much smaller that thermal velocity.[3]
The magnetized expression for the ion energy loss rate is derived by using the full magnetized Balescu-Lenard-Guernsey equation. It is found that as the ion velocity increases, the magnetic field first speeds up the ion energy loss and then slows down the ion energy loss.[4]
The expression for scattering angle is derived including the magnetic field. It is found that the scattering angle become smaller or larger due to the Larmor gyration enhancing or weakening the scattering.[5]
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[4] Chao Dong, Ding Li, and Chang Jiang, Stopping of energetic ions by collisions with electrons in a magnetized plasma. (Under preparation)
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