Banana kinetic equation and plasma transport in tokamaks

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In a high temperature fusion relevant tokamak plasma, effects of finite banana width are important to plasma dynamics. A banana kinetic equation that includes effects of finite banana width is derived for both electrostatic and electromagnetic waves with frequencies lower than the gyro-frequency, and the bounce frequency of the trapped particles [1,2]. The radial wavelengths are assumed to be either comparable to or shorter than the banana width but much wider than the gyro-radius. One of the consequences of the banana kinetics is that the parallel component of the vector potential is not annihilated by the orbit averaging process, and appears in the banana kinetic equation. The equation is solved to calculate neoclassical quasilinear transport fluxes in the superbanana plateau, and other collisionality regimes caused by both electrostatic and electromagnetic waves. The transport fluxes can be used to model wave and chaotic magnetic field induced thermal particle or energetic alpha particle losses in tokamaks. It is found that electrostatic turbulence induced transport losses are reduced as a result of the banana kinetics. On the other hand, the parallel component of the vector potential enhances losses when it is the sole transport mechanism. Especially, the drift resonance can cause significant transport losses in the chaotic magnetic field in the hitherto unknown low collisionality regimes. In general, it is the interference between the electrostatic, and vector potentials, that ultimately determines whether the banana kinetics enhances or improves the electromagnetic wave induced transport losses. The banana kinetics also provides an isotope scaling. The implications on energetic alpha particle confinement in ITER will be addressed.

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References

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