Multiple Timescale Derivative Expansion Approach Applied to Plasma Transport and Relaxation Theories

ABSTRACT

Based on a multiple timescale approach, recently the plasma transport equations have been derived for different timescales, where the parameter range of a typical weakly-collisional fusion plasmas (WCR) was assumed. On the Alfvén timescale the ideal MHD (IMHD) equations have been obtained. On the MHD-collision (CMHD) timescale the transport equations contain in addition to those turbulent terms, the higher order moments quantities which have to be determined. Based on the solution of the first-order distribution function, it is shown that on the CMHD timescale the obtained value for the radial heat flux is several orders of magnitude higher than the classical one in well agreement with the experimental observations and that the viscous stress tensor is strongly influenced by the zero-order force-free magnetic field. As a natural extension to this approach, the plasma transport equations for the two complementary regimes, namely for the intermediate- (ICR) and high-collisional (HCR) regimes are derived. In this respect, it is shown that the lowest order gyro- motion is unperturbed by collisions. On the Alfvén timescale, for both the ICR and HCR regimes, the IMHD equations are obtained if the slow-flowing condition is satisfied. On the CMHD timescale, contrary to WCR case, the obtained transport equations do not include turbulent terms. Finally, the multiple timescale approach is applied to prove Taylor's well-known conjecture. It is shown that during the evolution on the CMHD timescale the plasma behaves slightly non-ideal the case in which instead of the local magnetic helicity integral K^{Ψ} only the global one K is conserved a fact which is due to the driven magnetic reconnection