

On current drive and wave induced bootstrap current in toroidal plasmas

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Abstract

A comprehensive treatment of wave-particle interactions in toroidal plasmas including collisional relaxation has been obtained by using Monte Carlo operators satisfying quasi-neutrality. This approach enables a self-consistent description of wave particle interactions with both electrons and ions. The method is applied to the regime corresponding to the banana regime in the neoclassical theory.

The coupling between the radial particle flux and the parallel current in toroidal plasmas affects the net driven current and plasma rotation. The canonical angular momentum absorbed on passing particles results in current drive and rotation of the plasma. The momentum absorbed on trapped particles gives essentially rise to a toroidal rotation of the trapped ions that will be relaxed through collisions into a toroidal rotation of the plasma, but it gives also rise to a bootstrap like current. For ion current drive methods the additional bootstrap like current is parallel to the RF driven ion current, but for electron current drive it is opposite to the RF driven electron currents.

The use of Monte Carlo operators satisfying quasi-neutrality allows an extension into a regime with large temperature and density gradients, losses and transport of particles by wave-particle interactions making the method applicable to transport barriers. It is found that at large gradients the relationship between radial electric field, parallel velocity, temperature and density gradient found in neoclassical theory is modified such that coefficient in front of the gradient of the logarithmic ion temperature gradient, which in the standard in neoclassical theory is small and counteract the electric field caused by the density gradient, now changes sign and contributes to the built up of the radial electric field, thus enabling formation of transport barriers during strong ion heating.