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Poloidally Localized Fueling Effects on Toroidal Flow and Radial Electric Field

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Abstract

Neutrals at the edge of tokamaks can affect confinement by altering the radial electric field and toroidal plasma flow velocity through charge-exchange and ionization interactions. We show that the flow and electric field are very sensitive to the poloidal location of the neutrals and the ion collisionality. These predictions are consistent with differences observed on MAST between measured toroidal flows for inboard and outboard gas puffing, and may also explain observations indicating that inboard puffing allows easier H mode access [1]. In a collisional plasma the neutral kinetics is treated first in the short mean-free path limit and then for arbitrary mean-free path [2] by employing a self-similar neutral distribution function obtained for special temperature and density profiles [3]. The resulting neutral distribution function is used to investigate neutral effects on the ion flow and electrostatic potential as the neutral mean-free path varies from being very short to being comparable to the scale length of plasma density and temperature. In addition to recovering short mean-free path results, we find that neutral effects on the flow and radial electric field depend sensitively on the poloidal location of the neutrals, especially in a spherical tokamak. In particular, we find that the radial electric field and outboard toroidal flow velocity in a collisional edge plasma tend to be larger if the atoms are concentrated on the inboard side rather than on the outboard side - consistent with the MAST results and suggesting that the flow shear introduced by the neutrals is suppressing edge turbulence and playing a role in forming the edge transport barrier. These results are then shown to be sensitive to plasma collisionality by considering banana regime ions and collisional neutrals. In this case, larger outboard toroidal flow and radial electric field are obtained for outboard puffing - suggesting that outboard puffing could suppress edge turbulence and generate an edge transport barrier in tokamaks with less collisional edges.

[1] P. G. Carolan, et al, 19th IAEA Fusion Energy Conference, Lyon, France 14-19 October 2002, paper IAEA-CN-94/EX/C2-6-6, submitted to Nucl. Fusion.

[2] T. Fülöp, P. Helander and P. J. Catto, Phys. Rev. Lett. 89, 225003 (2002).

[3] P. Helander and S. I. Krasheninnikov, Phys. Plasmas, 3, 226 (1995).

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