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Abstract

Status of a Plasma Neutralizer development

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Neutral beam injection based on negative ions acceleration with further additional electron detachment became necessary in plasma experiments when the fusion devices have been grown up to sizes large enough to need beam energies in range of the 200-1000 keV/nucleon. In that range the accelerated positive ion charge exchange on gas or vapor targets becomes ineffective and negative ion stripping proves to be the only possible choice. The electron detachment can be provided with using several ways. Gas cell is the simplest neutralizer. If we would like to increase overall NNBI efficiency and decrease a gas load, we should use Plasma Neutralizer (PN). PN can provide the neutral fraction of initial deuterium negative ion beam up to 86% instead of 60% at the gas one.

The following PN concept was chosen: it is proposed to use a multipole magnetic trap of large volume with closed ∇B drift of electrons,. The steady state plasma should be produced by electrodeless microwave discharge at gas pressure less than 10^{-4} torr at mainly collisionless character of microwave energy absorption.

The main experimental results were obtained at PN model named PNX-U :

- It was confirmed that the concept is effective for production of "cold" plasma with high ionisation degree in a large volume.
- High Density (HD) mode was observed with plasma density higher then "cut-off" limit.
- An Argon plasma with parameters of $n_e \sim 10^{18}$ m^{-3} ($\sim 1.5 n_{cut\text{-}off}$), $T_e \sim T_i = 5 \div 10$ eV, $n_e/n_o \geq 0.4$ is produced in the volume ~ 0.5 m^3; line density up to $2x10^{18}$ m^{-2} is achieved.
- Potential plasma confinement was investigated. In HD mode the necessary microwave specific power input to the plasma is at the level of 0.05 MW/m^3.
- Some important effects and characteristics were investigated: multi charged ions generation, ion and electron temperature space distribution, plasma uniformity etc.

The PNX-U results demonstrate that plasma parameters necessary for ITER PN can be obtained with use of super-conducting magnetic system providing maximum field ≥ 1 T in the "magnetic slits". Gyrotron microwave source with frequency ~ 24 GHz is required ("cut-off" plasma density is ~ $7x10^{18}$ m^{-3}, resonant magnetic field value is about 0.86 T). The required microwave power input into the plasma is about 0.5 MW.