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Investigation of neutral particle transport in GAMMA 10 SMBI experiments
GAMMA 10 SMBI実験における中性粒子輸送解析

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SMBI system has been installed in GAMMA 10. SMBI is located at the bottom of the central-cell mid-plane. The first results of the SMBI experiment showed that SMBI achieved higher density plasmas at the core region than the conventional gas puffing case. A high-speed camera at the central-cell was used in order to observe plasma behavior during SMBI. In order to analyze neutral transport from SMBI fueling, three-dimensional Monte-Carlo simulation code has been applied to GAMMA 10. In this paper a discussion on the neutral transport due to SMBI follows a comparison between the experimental results and simulations.

1. Introduction

Control of gas fueling is one of the most important issues to obtain good performance plasmas. Fueling control enables the profile control of the core plasma density and reduction of neutral particles in the peripheral area. Supersonic molecular beam injection (SMBI) technique, which has been developed by L.Yao et al.[1], is a new method of gas fueling. SMBI can inject neutral particle deeper into the core plasma compared to the gas puffing. SMBI is successfully applied to some devices [2, 3].

GAMMA 10 is open magnetic plasma-confining device [6]. SMBI is located at the bottom of the central-cell mid-plane. The central-cell has a simple solenoidal magnetic configuration by a number of pancake coils. In addition, GAMMA 10 has many observation ports. Thus, GAMMA 10 is suitable for analyzing the neutral transport. The first results of SMBI showed that SMBI achieved higher density plasmas at the core region than the conventional gas puffing case. The purpose of this study is that the neutral particle behavior due to SMBI is investigated based on three-dimensional Monte-Carlo simulation.

2. Experimental set up and the typical results

GAMMA 10 consists of central-cell, anchor-cells, plug/barrier-cells and end-cells. Mid-plane of the central-cell is located at z = 0 cm and west and east correspond to plus and minus in z-axis respectively. The central-cell is the main region to confine plasma. Mirror-throat regions which exist between the central-cell and anchor-cell have the first mirror with strong magnetic field for confining the plasma in the central-cell. The initial plasma is produced by plasma guns located in both ends. Then plasma is produced and heated by ion cyclotron range of frequency (ICRF) waves. Two conventional gas-puff systems are installed for sustaining plasma at both mirror throat region.

Figure 1 shows the cross-section view of the GAMMA 10 central-cell and locations of the high-speed camera and SMBI system. A high-speed camera has been installed at central-cell in order to observe the plasma behavior. The camera system has two lines of sight in the horizontal and vertical directions of the plasma cross-section by using dual blanch optical fiber bundles. SMBI system consists of a fast solenoid valve with a magnetic shield. The plenum pressure is usually 1MPa and pulse width is 0.5-1.0 ms. SMBI pulse was injected to typical plasma heated by only ICRF. Figure 2 shows 2-D image of visible light-emission from GAMMA 10 plasma by high-speed camera. Z-axis distribution of the emission intensity was estimated based on this 2-D image.

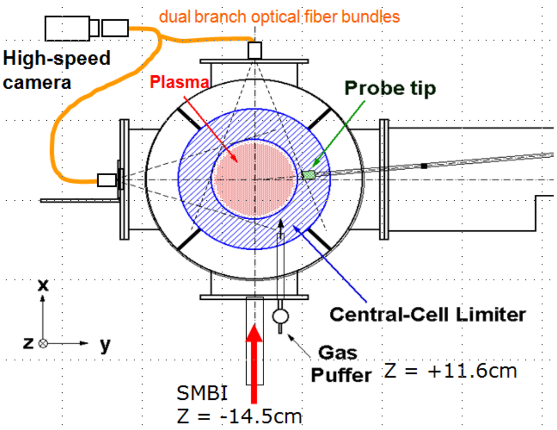

Fig.1. Cross-section view of the GAMMA 10 central-cell and locations of high-speed camera and SMBI system

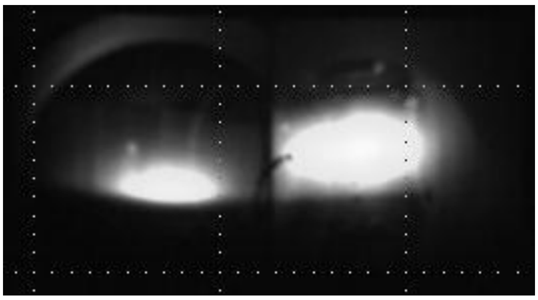

Fig.2. 2-D image of plasma during SMBI injection. (left side: horizontal   right side: vertical)

3. Simulation model

Monte-Carlo simulation code (DEGAS [5]) was used in order to analyze the behavior of neutral particle in GAMMA 10 [6]. Three-dimensional mesh-model for DEGAS has been applied to the central-cell [7]. The mesh-model was upgraded for modeling of SMBI experiment as shown in Fig. 3. The dependence of diffusion degree was investigated in order to interpret the configuration of diffusion corresponding to the results of SMBI experiments. Figure 4 shows the dependence of z-axis distribution of emission intensity on the diffusion degree. In the case of cosine distribution, the diffusion degree is 1. In the case that the diffusion degree is 1/2, that means a half of diffusion of cosine distribution. Maximum value of intensity of each distribution was normalized 1 in Fig. 4.

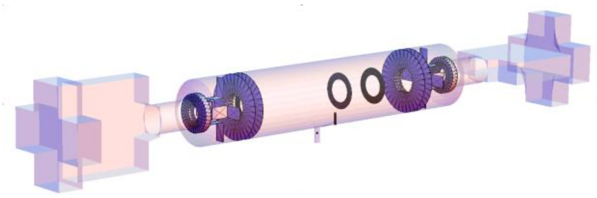

Fig.3. The fully 3-dimensional DEGAS mesh model

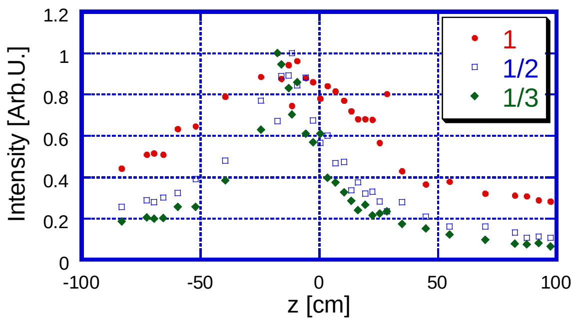

Fig.4. The dependence of z-axis distribution of emission intensity on the diffusion degree.

4. Summary

Using 3-D Monte-Carlo simulation code, the neutral transport in the GAMMA SMBI experiments were simulated. A profitable finding of the neutral transport due to SMBI will be obtained by discussing a comparison between the experimental results and simulations.

Acknowledgments

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