§12. Orbital Aspects of Reachable β Value in NBI Heated Heliotron/Torsatrons[1]

Murakami, S., Nakajima, N., Okamura, S., Okamoto, M.

Physics of high β plasma is one of the important issues for developing the efficient future fusion reactor. Many experimental and theoretical studies have been done not only in tokamaks but also in heliotron/torsatrons. Recently the high β experiments in the CHS (Compact Helical System) show the highest averaged β value in heliotron/torsatrons as $\langle\beta\rangle$ = 2.1%[2]. Since the large Shafranov shift occurs in finite β in heliotron/torsatrons it is necessary to take this configuration change into account for evaluating the heating efficiency in finite β. In this paper the efficiency of the NBI heating is analytically derived in finite β using the calculated beam deposition profile and beam particle orbit. Large drift orbit deviation of tangentially injected NBI particle from the original magnetic surface occurs to enhance the prompt orbit loss and diminish the heating efficiency when the strength of magnetic field is small. It is found that the configuration changes due to the finite β effects alter the NBI heating efficiency largely and that the magnetic well or hill condition, which is important for the MHD stabilities, is also an important factor to determine the heating efficiency in a weak magnetic field. By combining the energy confinement scaling law the plasma β is evaluated. It is found that there is the optimum value of the magnetic field to obtain the high plasma β in a point of view of the NBI heating efficiency.

Next our model is applied to the CHS plasma and compared with the results of high β experiments. Fig. 1 shows the heating efficiency as a function of magnetic field strength for configurations with different β (co injection case with E_b = 40keV and $\bar{n} = 0.55 \times 10^{14}\text{cm}^{-3}$). Combining the LHD scaling we evaluate the plasma β using consistent configuration with obtained β value (Fig. 2). The results agree well with the high β experiments in the CHS. It is found that the effects of beam particle orbits play an important role to determine the reachable β value in the CHS experiments.

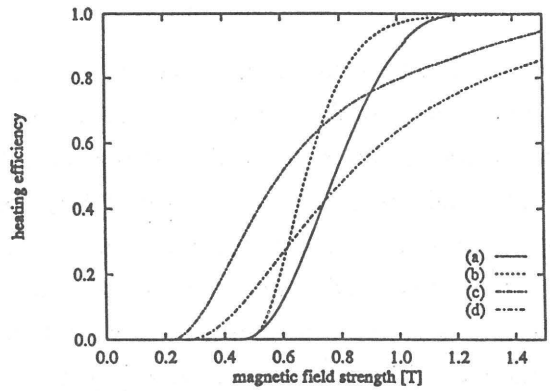

Fig. 1: *Heating efficiencies of tangentially injected NBI heating in the CHS as a function of the magnetic field strength, B, for configurations with different β; (a)β = 0.0%, (b)β = 0.84%, (c)β = 1.83%, and (d)β = 2.38%.*

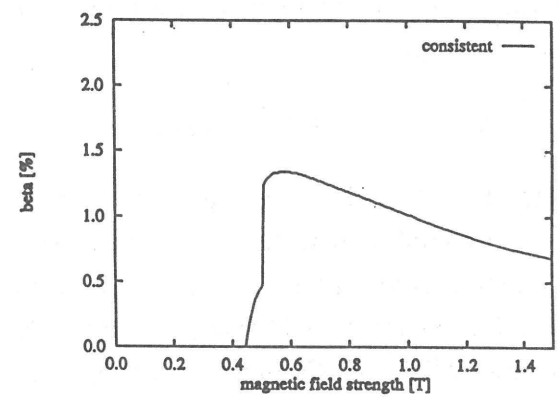

Fig. 2: *Plots of the averaged beta values, β, as a function of the magnetic field strength, B, using the consistent configurations with obtained β values.*

References

1) Murakami, S., et al., to be published in Nucl. Fusion, NIFS-354 (1995).

2) Okamura, S., et al., Nucl. Fusion 35 (1995) 283.