§50. Orbit Studies of Fast Ions Produced by Neutral Beam Injection on QUEST (Q-shu University Experiment with Steady State Spherical Tokamak)

Osakabe, M., Takeiri, Y., Nagaoka, K., Zushi, H., Hasegawa, M. (Kyushu Univ.)

The experiments on QUEST (Q-shu University Experiment with Steady state spherical Tokamak) will start in 2008. One of the main aims of this experimental project is to explore the steady state operations of high-beta plasmas with spherical tokamaks (ST). This includes the establishment of the current drive scenario which is suitable for sustaining the high-beta and high-performance ST plasmas.

The neutral beam (NB) injection is one of the most common methods in heating plasmas and in driving currents in various toroidal plasmas, and is applied for several ST plasmas[1,2]. On QUEST, the NB injection is also considered as a heating and current drive tool. In designing the geometry of the NB injection, orbits of injected fast ions are tracked by solving the Lorenz-force equation instead of solving guiding center equation. The $\rho \nabla B / B$ of fast ion in ST might be sometimes large enough to break the conservation of magnetic moment(μ) since the magnetic field strength is weak (Bt$\leq$0.5[T] on QUEST) and the aspect ratio is small (R/a = 1.78 on QUEST) in ST compared to those in conventional tokamaks.

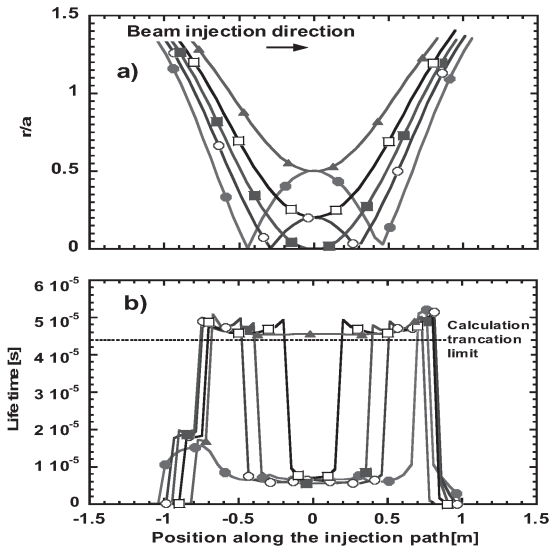

Fig.1 (a)The normalized minor radii distribution along the tangential NB-injection path. (b)The life time distributions of 20keV protons which are lunched from the tangential NB-injection path. The lines with closed circles (●), open circles(○), closed squares(■), open squares(□), and closed triangles(▲) correspond to the tangency radii(R_t) of 0.5m, 0.6m, 0.67m, 0.73m and 0.82m, respectively.

The tangency radii(R_t) of NB injection were surveyed in order to find an optimum condition for NB injection for the QUEST standard configuration (Bt=0.5[T]/Ip=200 [kA]) as shown in Fig.1. In this figure, the life times of 20keV protons being launched from the NB-injection path are shown. The NB is assumed to be injected to co.-direction to plasma currents to enhance the currents. As shown in the figure, the confined region along the NB-injection path is the largest when the R_t equals to 0.82[m] and these regions becomes smaller as the R_t becomes smaller. This is mainly due to the weak poloidal magnetic field strength being produced by a low plasma current. On QUEST, it is found that the NB should be injected at the region where R_t is greater than the magnetic axis radius to have better heating efficiency by the beam. Further optimization of NB injection is necessary to investigate the better current drive efficiency.

This work is supported by a NIFS-universities collaboration program (NIFS05 KUTR011).

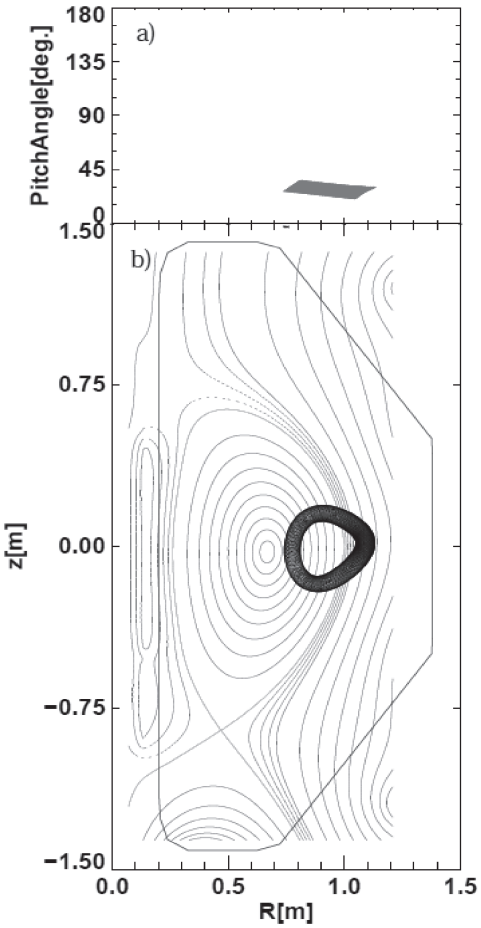

Fig.2 An example of confined co-going particles on QUEST. (a) Pitch angle distribution are shown in red-lines and (b) poloidal projection of the orbits are shown in black lines.

1) R. J. Akers, *et.al.*, Nuclear Fusion, Vol.42, pp.122-135 (2003)
2) W. W. Heidbrink, *et.al.*, Nuclear Fusion, Vol. 43, pp.883-888 (2003)