§50. Orbit Study of Energetic Particles on QUEST (Q-shu University Experiment with Steady State Spherical Tokamak)

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The plasma boundary dynamics experimental device (QUEST) is a low aspect ratio spherical tokamak (ST), which is under construction at Kyushu University. The objectives of the QUEST are to realize long-pulse steady-state plasmas and to investigate their plasma properties including the related engineering aspects. In order to achieve high-density steady-state plasmas, the plasma heating and current drive by 40-keV neutral beam injection (NBI) is considered [1].

To investigate the confinement properties of energetic particles produced by the NBI, we have developed an orbit following code for QUEST. Since the magnetic field strength is extremely low on QUEST (Bt=0.25[T]), we have used a full-orbit following method by solving the Lorentz-force equation instead of a guiding-center method.

As a first trial, we have calculated energetic particle orbits in the QUEST magnetic configuration of Bt=0.25[T] / Ip=100[kA], which will be applied to the steady-state operation sustained mainly with the RF current drive. Figure 1 shows the poloidal projection of the typical orbits for co.-going particles in this configuration. The particles are launched from (R, Z) = (0.5[m], 0.0[m]) in this figure. The confinement of 40-keV protons is poor in this configuration. We need to optimize the confining magnetic field and the structure of in-vessel components for the NBI heating in this magnetic configuration.

Figure 2 shows the results of the poloidal field scan in the orbit following calculations. As is shown in this figure, an increase in the poloidal field is effective for confining 40-keV protons since it reduces the width of a banana-orbit. It is necessary to increase the poloidal field strength at least 5 times larger than the original one.

We are going to apply this orbit following code to the magnetic configuration of Bt=0.5[T] / Ip=300[kA] for the NBI heating and current drive. Further calculations of the energetic protons in the QUEST second-phase configuration are also necessary to determine the shape of the plasma facing wall and to optimize the NBI-heating scenario on QUEST.

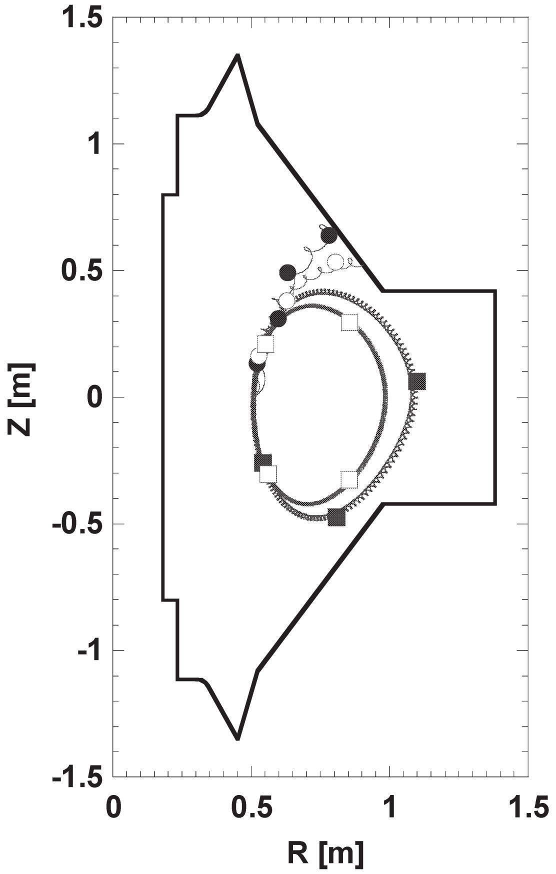

Fig.1 Poloidal projection of the typical orbits in the first-phase configuration of QUEST (Bt=0.25[T]/ Ip=100[kA]). The energies of the particles are 40-keV (lines with closed circles), 20-keV (lines with open circles), 10keV (lines with closed squares) and 5-keV (lines with open squares).

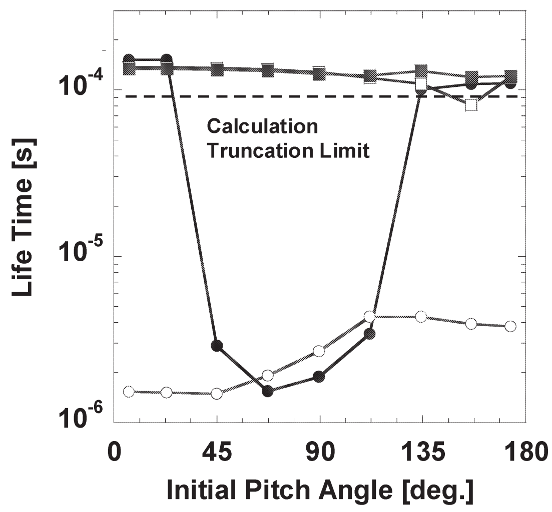

Fig.2 Poloidal field dependence of the calculated life time for 40-keV protons in the QUEST plasmas. The launching points are set at (R, Z)=(0.5[m], 0[m]) in these calculations. Lines with open circles show the case with the original poloidal field strength of QUEST Ip=100[kA] configuration. Those with closed circles, open squares and closed squares show the cases where the poloidal field strength is multiplied by a factor of 2, 5 and 10 from the original one,

Reference
[1] Takeiri, Y., et al., Annual Report of NIFS 2006, p.524