## §22. Spatial Distribution of Losses of Neutral Beam-injected Fast Ions in Quasi-axisymmetric System

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The quasi-axisymmetric system (QAS) provides good neoclassical confinement as well as magneto-hydrodynamic stability while realizing tokamak-like, toroidally-symmetric magnetic field structure on the Boozer coordinates[1]. However, it is required to verify whether energetic ions can be well confined in QAS because even if neoclassical confinement is much better than that in conventional helical system like CHS, it does not guarantee good confinement property for energetic ions. In a tokamak, it is well known that ripple loss of energetic ions makes localized heat spot on the first wall due to finite number of toroidal coils[2]. Such a local heat load has to be avoided because it may give serious damage to the device. QAS is analogous to a rippled tokamak in magnetic field structure because residual non-axisymmetric magnetic field ripples still exists in QAS's peripheral domain. Therefore, the similar situation may appear in the viewpoint of energetic ion loss. In this work, we investigate spatial loss distribution of energetic ions originating from neutral beam injection and check how much localized it is. The orbit analysis is performed by use of the DELTA5D code[3,4]. The DELTA5D follows guiding center orbits in the presence of slowing-down and pitch angle scattering processes on the Boozer coordinates. The equilibrium magnetic field is obtained from the VMEC code. The target QAS configuration has toroidal periods of 2, aspect ratio of 3.2, major radius of 1.5m and toroidal magnetic field of 1.5T[5].

Figure 1 shows energy distribution of escaping beam ions from the QAS plasma. The neutral beam is tangentially co-injected and its injection energy is set to be 38 keV. The detailed plasma parameter used in this analysis is well described in Ref.6. The beam ion losses begin after they slow down to 30 keV. The primary losses of partially thermalized beam ions is supposed to be due to ripple trapping in a ripple well existing in the peripheral region. This is because the DELTA5D shows that pitch angle $v_{//}/v$ of escaping ions is very localized and ranges from 0 to 0.03. Next, we show the spatial distribution of losses of escaping beam ions in Figure 2. Dots represent the location where beam ions intersect the last closed flux surface of QAS. It can be seen that beam ion losses take place in the lower half of the plasma because ion grad-$B$ drift is directed to be downwards in this case. The losses are not uniform and are somewhat localized in the particular toroidal angle. This loss pattern is quite different from that in CHS. The ripple loss in CHS mainly appears in the small major radius side due to helically trapped ions.

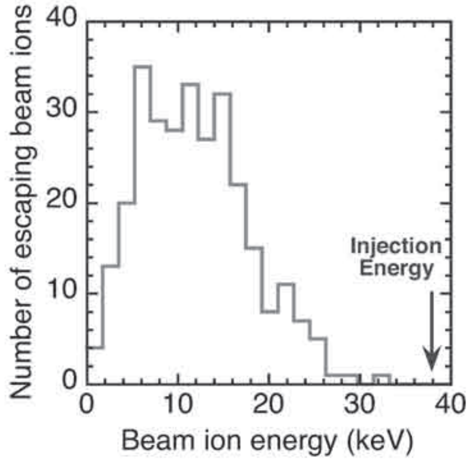


Fig. 1. Energy distribution of escaping beam ions in QAS. Beam ions are tangentially coinjected with $E_b$ of 38keV

Fig. 2. Spatial distribution of losses of escaping beam ions in the Cartesian coordinates.

References
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