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# Characteristics of fast ions profile with MHD activities and improvement of fast ion confinement with AE suppression by counter-ECCD in LHD

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Characteristics of fast ion profile with MHD activities have been investigated in LHD deuterium experiments. The beam deposition profiles are changed by means of the selection of the operational ion source in tangential NBIs. Two ion sources are mounted on tangential NBIs with different tangential radius, therefore, the combination of ion sources operation and plasma position control enables us to change the beam deposition profiles in LHD plasmas. The demonstration of fast ion profile control without any Alfven eigenmode (AE) activity ($V_{\mathrm{fastion}} < V_{\mathrm{Alfven}}/3$) was carried out. Qualitative agreement of neutron emission profile was obtained between the numerical calculation (GNET code [1]) and the experimental observation with the vertical neutron camera (VNC) [2].

In the case of existing MHD activity ($V_{\mathrm{fastion}} > V_{\mathrm{Alfven}}/3$), two types of characteristic of fast ion profiles were identified depending on the bulk plasma density. In low density regime, experimentally observed fast ion profiles are independent of the beam deposition profile, which is very similar to the profile stiffness observed in DIII-D plasmas [3] and in a hybrid simulation [4]. On the other hand, in the high density regime, the fast ion profile changes depending on the beam deposition profile.

The effects of ECH and ECCD application on the fast ion confinement characteristics have also been investigated in low density regime where the experimentally observed fast ion profile exhibits profile stiffness properties. In the case of ECH application, no clear changes of neutron emission were observed, although some changes in AE activity were observed. On the other hand, in the case of ECCD application, clear stabilization of AEs with counter-ECCD and destabilization of AEs with co-ECCD were observed. The neutron emission was significantly enhanced when AEs were stabilized with counter-ECCD application. The smaller neutron emission with co-ECCD was observed in comparison to those in ECCD-free cases, although the electron temperature is almost double in the plasma with the co-ECCD application.

The experimental results demonstrated that the fast ion profiles in low density regime with AE activity exhibits profile stiffness properties, and the ECCD application has the capability to overcome the profile stiffness properties and to improve fast ion confinement of fast ions through suppression of AE activity.

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