Study of beam ion anisotropy using multi-sightline CLYC7-scintillator-based compact D-D neutron spectrometers

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Studying fast-ion physics in fusion plasmas plays an important role in making effective plasma heating and achieving high-performance plasmas. Neutron spectrometry is one of the superior methods to diagnose fast-ion's velocity distribution in a fusion plasma core because in a neutral-beam (NB)-heated plasma, fusion neutron is dominated by neutron resulting from so-called beam-plasma reaction. Therefore, neutron spectrometry can contribute to deeper understanding of the excitation mechanism of beam-ion-driven magnetohydrodynamic (MHD) instability which is one of the key topics for magnetic confinement fusion.

In this work, we applied the novel compact neutron emission spectrometer (CNES) to deuterium plasmas in the Large Helical Device (LHD). Anisotropy of beam ion's velocity is of great concern in the LHD since fast-ion-driven MHD modes are often destabilized due to high-energy NB injection based on negative-ion source (N-NB) [1]. Three new CNESs based on novel inorganic scintillator Cs_2LiYCl_6:Ce with 99% ^{7}Li-enrichment (CLYC7) having different tangency radii were installed in the LHD. It should be noted that the CLYC7 scintillator can directly measure the D-D neutron energy through the ^{35}Cl(n,p)^{35}S reactions unlike a conventional organic liquid scintillator, e.g. EJ-301. In this LHD campaign, we observed the Doppler shift of the D-D neutron energy resulting from the anisotropy of fast ions injected by tangential N-NB injection by the CNESs with multiple lines of sight at 6-T, 8-O, and 10-O ports.

We also have compared the D-D neutron spectra observed in the experiment and that predicted by a numerical simulation. The detailed experiment setups of the CNESs in the LHD and the results of D-D neutron spectroscopy during N-NB injection heating will be presented.

[1] K. Toi et al., Fusion Sci. Technol. **58** (2010) 186.