Vibrational states of hydrogen molecules in one third LHD negative ion source

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Neutral beam injector (NBI) is one of most essential devices for fusion plasma heating and sustainment. NBI consists of usually positive/negative ion source and neutralizer. Negative ion based NBIs have been developed and been utilized in the Large Helical Device (LHD). The production of hydrogen negative ions is considered to be a competitive production between so called “volume” and “surface” production in a negative ion source. For the comprehension and optimization of ion sources, the diagnostic of hydrogen atoms and molecules is one of effective approaches, because those atoms and molecules give an origin to negative hydrogen ions. In particular, negative hydrogen ions as volume production are produced by vibrationally excited hydrogen molecules through the dissociative electron attachment. In a small negative ion source, the emission spectrum originated from C-X and B-X transitions of hydrogen molecules were measured by a vacuum ultraviolet (VUV) spectroscopy. The vibrational temperature of hydrogen molecules is found to be 300 K.

A large size negative ion source for NBI usually uses cesium vapor admixture in it to enhance negative ion beam currents. The behavior of vibrationally excited states of hydrogen molecules is not clearly understood under the cesium admixture operation. At NIFS, we prepared the VUV spectrometer for the one third scale negative ion source. Since the input power and the volume are comparable to the real size negative ion source for LHD NBI system, it is expected that progress will be made in understanding of the negative ion production.

The VUV spectrometer has been changed from a detector of a photomultiplier to a CCD camera, which can reduce the acquisition time from ~ ten minutes to ~ millisecond in the wavelength range of 100-160 nm. The sightline of the VUV spectrometer can be chosen in accordance with experiments in the driver and the extraction regions. The atomic lines for Lyman system are more intense than those in the small negative ion source. This would be related to the ionization degree and the electron temperature. The emission band spectrum from C-X and B-X transition in cesium admixture case is decreased by ~10 %, compared with pure discharge case. This would be caused by the reduction of electron density in the extraction region. The result indicates no/weak cesium effect for vibrationally excited hydrogen molecules. That is, there is no/weak correlation with volume production of H^-. Since the H^- beam current increases a few or more in cesium admixture case, the cesium admixture enhances the surface production of H^- in the extraction region. The result also supports the small ion source result that there is the correlation between the work function reduction and the n_-/n_e ratio increase [2]. However we still need discussion because of no clear correlation between the absolute n_- in the small ion source.

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[2] Masaki Nishiura, J. Plasma and Fusion Res. **80**, 757-762 (2004).