Cavity ring-down spectroscopy for H^- density measurement on 1/3 negative ion source of LHD-NBI

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Negative ion based Neutral Beam Injectors (nNBIs) on Large Helical Device (LHD) have been performed with nominal beam energy (188 keV) and power (5 MW) for each injector. It seems that no fatal problems of withstand voltage and heat load are in acceleration system and beam line. The operation stability of nNBI is not high compared with positive ion based NBI. This is regard as using cesium (Cs) for the surface production of negative hydrogen ion (H^-). To improve the operation stability, it is important that the relation among behaviors of Cs, H^- and temperature of plasma grid (T_{PG}) which faces an ion source plasma during beam extraction. Although cesium density and T_{PG} have been already measured in nNBI on LHD, H^- density has not measured yet.
We applied Cavity Ring-Down laser absorption Spectroscopy (CRDS) to H^- density measurement in the 1/3 negative ion source of LHD-NBI. CRDS is optical measurement and can work in beam extraction. Absolute density can be measure with CRDS. The measurement principle of CRDS is followings. A laser plus is injected to input side of a high reflective mirror of an optical cavity. The laser light gradually exits both side of the mirror with reciprocating in the cavity. The light intensity from the output side mirror gradually decays as is shown in Fig. 1, even if no measuring object is in the cavity. If measuring object which reacts input laser is in the cavity, the decay time (ring-down time) decrease. The density can be evaluated by comparing the ring-down time with the measuring object to that without one.
In the CRDS system on the 1/3 negative ion source, the fundamental wave of Nd:YAG laser (1064 nm) is applied, the cavity length is 1.2 m, the reflectivity of cavity mirror is 99.996% @1064nm, and the band width of a photo detector is more than 1 MHz. The absolute density of the volume production H^- has been measured with CRDS (Fig1). The density has been confirmed as the same order of the density estimated H^- beam current. The tendency of the arc power dependence of H^- density (Fig. 2) is similar to that of H^- beam current.

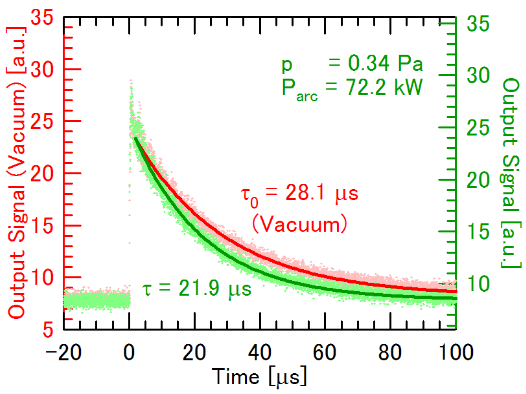

Fig. 1 Ring-down signals are detected with and without plasmas. Comparing decay times of ring-down signals, negative hydrogen ion density is 3.3×10^{16} m^{-3}.

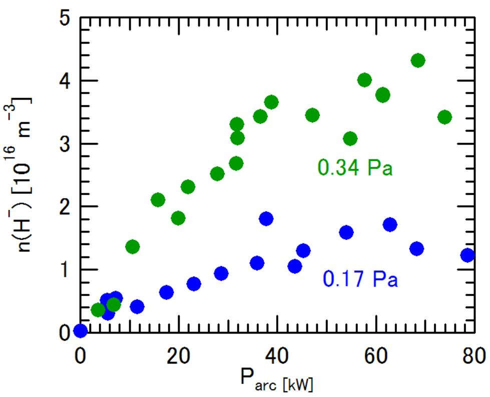

Fig. 2 Arc power dependence of negative ion density measured with cavity ring down spectroscopy. The measuring position is 8 mm far from plasma grid.