§14. Measurement of Electron Density in a Negative Ion Source with Interferometer

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Supression and control of electron density are one of the most important key issues for development of high performance negative ion sources. In order to investigate the electron behaviors, a millimeter-wave interferometer with the frequency of 39 GHz ($\lambda = 7.7$ mm) is installed on a large-scaled negative ion source. Measurable line-integrated electron density ($n_e l$) is from 2×10^{16} to $7 \times 10^{18} m^{-2}$, where the ne and l are respectively the electron density and plasma length through the millimeter-wave path, of which center is 1.2 cm far from the plasma grid. Figure 1 shows a cross section of the negative ion source, and line of sight is also shown.

The arc power was scanned based on shot by shot basis in the condition without cesium seeding, which is shown in Fig. 2. The observed electron density increases linearly with arc power, indicating that the interferometer works well in the wide range of electron density.

In order to investigate the cesium seeding effect on electron density and negative ions density, the sequential operation of arc discharge in every two minutes were carried out. Figure 3 (a) shows the time evolutions of electron density measured by the interferometer. The electron density decreased with a factor of around 5 was observed in the initial phase within 50 min after the start of cesium seeding. The quite similar result was obtained by Langmuir probe, which is shown in Fig. 3 (b). The absolute value of electron density also agrees well between the interferometer and Langmuir probe. The difference is only within a factor of 1.6.

The interferometer and cavity ring down spectroscopy can determine the absolute value of density with geometrically identical line of sight. Therefore the negative ion density ratio R $(= n_{H^-}/(n_e + n_{H^-}))$ can be determined with very high accuracy. The negative ion density ratio without cesium seeding is $R = 0.17$, and it becomes $R = 0.73$ within 50 min. after the start of cesium seeding. Finally $R = 0.85$ was achieved at 400 min. from the start of cesium seeding.

From these preliminary experiments, it is concluded that an interferometer is useful to measure the electron density near the beam extraction region of negative ion sources.

1) K. Nagaoka, et al., Presentation at *2nd international symposium on negative ions, beams and sources*, P2-32, Nov, 2010, Takayama city, Japan.

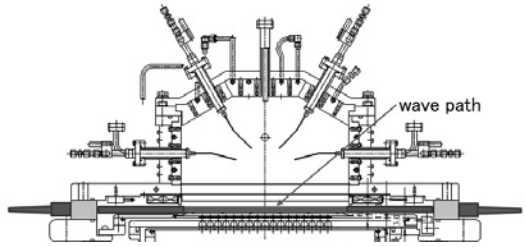

Fig. 1: Schematic of the cross section of the 1/3rd scaled negative ion source for LHD-NBI system.

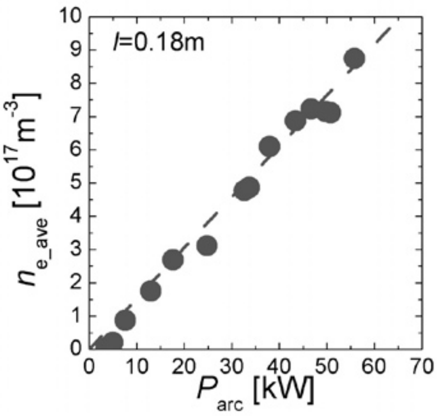

Fig. 2: Line-averaged electron density as a function of arc power with the condition of no cesium seeding.

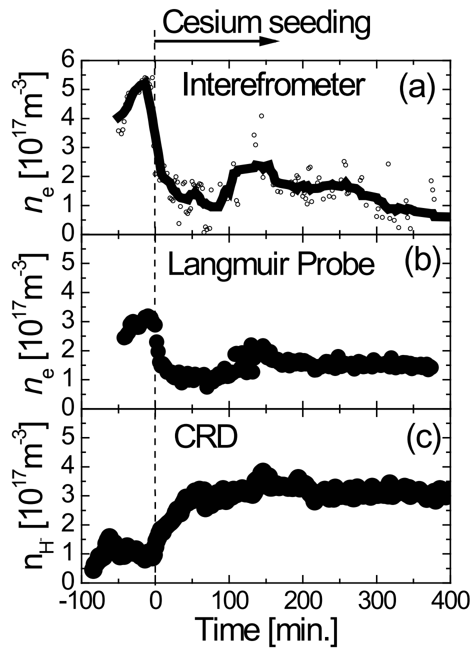

Fig. 3: Electron density measured by (a) interferometer and (b) Langmuir probe, and (c) negative ion density measured by cavity-ringdown spectroscopy.