High density hydrogen plasma for negative hydrogen ion production in HELicon Experiment for Negative ion source (HELEN-I)

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Large-scale fusion reactors like ITER are going to require very high-energy neutral beams (>1MeV) for plasma heating purposes as well as diagnostic neutral beams. To realize this, negative ion sources are a better alternative to the conventional positive ion sources because of their higher efficiency of neutralization. The helicon plasma sources are yet another advancement on the conventional inductively coupled plasma sources to produce high-density plasma for the production of negative hydrogen ions (H\textsuperscript{−}). HELicon Experiment for Negative ion source (HELEN-I) is developed with a focus on the volume production of negative hydrogen ions. In the Helicon wave heated plasmas very high plasma densities can be attained in the source region. The plasma expands in a diverging field into the expansion chamber where the electron temperature is low and the plasma conditions are conducive to the high production rate and low destruction rate of negative hydrogen ions without the use of a low function material like Caesium in the chamber. The low electron temperature is achieved in the expansion chamber with the magnetic and geometric expansion of the plasma without the use of filter fields. The present helicon source using permanent magnets is a cost effective and incredibly convenient alternative in terms of handling and maintenance as compared to the conventional caesium based negative hydrogen ion sources. In HELEN device at IPR, a Hydrogen gas helicon plasma is produced in a diverging magnetic field inside the source volume by applying RF Power of 13.56 MHz at 800-1000W using a Nagoya-III antenna for exciting m = \pm 1 azimuthal mode in the plasma. The plasma diffuses into the expansion volume where it is confined by a multiline cusp field. The characteristic density jump from inductively coupled mode to Helicon mode is observed at Prf ~ 800W with plasma density \( \sim 10^{18} \text{ m}^{-3} \) and electron temperature \( \sim 1-2 \text{ eV} \). The negative hydrogen ion density is measured in the expansion volume by Spectroscopy and Cavity Ring Down Spectroscopic technique and lies in the order of \( 10^{16} \text{ m}^{-3} \).