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Investigating the origin of the pressure dependence on the beam divergence at an RF negative hydrogen ion source

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Negative hydrogen ion sources for fusion rely on the surface conversion of hydrogen atoms and/or positive ions to H^- on low-work function (caesiated) surfaces. A low source filling pressure of 0.3 Pa is required to minimize stripping losses in the accelerator at ITER. Particularly in RF sources, the beam divergence depends strongly on the pressure –between 0.4 Pa and 0.3 Pa the divergence increases by 20%. The higher divergence is attributed to a higher temperature of negative ions, possibly originating from more energetic precursors. This opens up the question whether the energy distribution of the precursors and/or the relative relevance between the H^- production channels from H atoms and H_x^+ changes with the filling pressure.
BATMAN Upgrade is a test facility equipped with a single-driver RF source with unique diagnostic capabilities. Beside beam tools such as CFC tile calorimetry and Beam Emission Spectroscopy to determine the beam divergence, a manifold of plasma diagnostics are available to characterize H^- and its precursors: Cavity Ring-Down Spectroscopy for n_{H^-}, Two-photon Absorption Laser Induced Fluorescence for n_H and T_H, Langmuir probes for $n_{H_x^+}$ and the plasma potential distribution, and a Mach probe for determining net fluxes of positive ions. In addition, a LED-based diagnostic gives access to the work function of the convertor surface and thus to the conversion probability and energy loss of precursors during H^- production. Exemplarily, at 0.3 Pa a higher plasma potential drop from the plasma generation region to the H^- production region is observed – possibly causing, in combination with the reduced collision rate at lower pressure, a more energetic flux of positive ions onto the convertor surface.
This contribution summarizes the present insight into the physics of the source filling pressure dependence on the precursor properties, the relevance of the production channels and the beam divergence.

Primary author: WIMMER, Christian (Max-Planck-Institut f. Plasmaphysik)

Co-authors: YORDANOV, Dimitar (Max-Planck-Institut f. Plasmaphysik); WÜNDERLICH, Dirk (Max-Planck--Institut f. Plasmaphysik); KNAACK, Jasper (Max-Planck-Institut f. Plasmaphysik); HÖRSCH, Julian (Max-Planck--Institut f. Plasmaphysik); FANTZ, Ursel (Max-Planck-Institut f. Plasmaphysik)

Presenter: WIMMER, Christian (Max-Planck-Institut f. Plasmaphysik)

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