# From surface production to extraction in negative hydrogen ion sources: diagnosing $H^-$ and its precursors

Ch. Wimmer, J. Berner, A. Heiler, F. Merk, D. Zielke, U. Fantz and the NNBI-team

*Max-Planck-Institut f. Plasmaphysik, Garching, Germany*

Sources for negative hydrogen ions are used for certain particle accelerators as well as for neutral beam injectors of fusion devices. Efficient negative ion production relies in many cases on the surface production, where hydrogen atoms and positive ions produced in a low-temperature, low-pressure plasma are converted on a low work function surface. In order to lower the work function of the plasma exposed surface, caesium is injected into the source to form thin layers close to the extraction aperture(s). The conversion probability strongly depends on the surface work function and the incident energy of the conversion particle; the amount of produced negative ions depends in addition on the flux of conversion particles onto the surface. Thus, the experimental measurement of these parameters is of high interest.

BATMAN Upgrade is a test facility where the prototype RF negative hydrogen ion source for the ITER neutral beam injection system is installed. A unique variety of diagnostic tools are available to characterize the extended boundary layer, which is the plasma close to the extraction system where the production of negative ions, their transport through the plasma and their extraction takes place. Recently, two new diagnostic methods have been successfully established: a novel LED-based photoelectric work function measurement suites to characterize the work function and its temporal dynamics, in combination with the well-established tunable diode laser absorption spectroscopy (TDLAS) measuring the density of caesium atoms. Also novel for ion sources is the measurement of the flux and energy distribution of hydrogen atoms via a two-photon absorption laser induced fluorescence (TALIF) diagnostic. Together with the flux measurement of positive ions by a Mach probe and the measurement of the negative ion density by cavity ring-down spectroscopy (CRDS), a wide range of parameters is now accessible.

This contribution covers new insights that have been gained with this complementary set of diagnostics; among them is a surprisingly low work function of the conversion surfaces below the one of bulk Cs. The relative role between hydrogen atoms and positive ions for the production of negative ions is estimated and compared to the amount of negative ions. Particularly the isotope effect, where deuterium shows a higher atomic and negative ion density as well as a stronger temporal dynamics compared to hydrogen, is discussed.