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The high-energy tail of the EEDF and its impact on H^- volume ion sources

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Volume production of negative hydrogen ions relies on the dissociative attachment process by which low-energy electrons attach to highly vibrationally excited molecules ($H_2(v^*)$), the latter being produced predominantly by high-energy electrons. Understanding the processes leading to high $H_2(v^*)$ populations gives the opportunity to optimize H^- volume sources. This contribution focusses on a modelling approach to relate the electron energy distribution function (EEDF) to the obtainable vibrational populations and the subsequent H^- density in the source. The high energy-tail of the EEDF is of particular interest and its importance is highlighted in filament sources where primary electrons of high energy are present due to the arc voltage that drives the arc discharge [e.g. Terasaki et al., RSI 81 (2010) 02A703].

The modelling is based on the flexible Yacora solver: collisional-radiative models for the electronic H_2 states [Wünderlich et al., J. Phys. D 54 (2021) 115201] and the vibrational states of the molecular ground state (including redistribution via the singlet states ^{1}B and ^{1}C) [Bergmayr et al. Eur. Phys. J. D 77 (2023) 136] are used together with a balance model for the production and destruction channels of H^- [Rauner at al., AIP CP 1655 (2015) 020017]. The Yacora solver accepts arbitrary EEDFs, which gives the opportunity to analyse the impact of variations of the high-energy tail of the filament sources and compare it to a Maxwellian distribution that is more representative for RF driven discharges. Overall, the analysis suggests that the impact of the EEDF on the H^- density can be significant, i.e. a factor of two or more. The anticipated influence of varying the arc voltage on the EEDF is studied and compared to H^- beam current measurements done on the D-Pace filament ion source test stand. An outlook is given, showing the capabilities of using VUV spectroscopy to obtain empirical insights into the variation of the EEDF.

Primary author: FRIEDL, Roland (University of Augsburg, AG EPP)

Co-authors: TARVAINEN, Olli (STFC); FANTZ, Ursel (Max-Planck-Institut für Plasmaphysik); GEORGE, Anand (D-Pace)

Presenter: FRIEDL, Roland (University of Augsburg, AG EPP)

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