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Powerful plasma sources for negative hydrogen ions: a challenge to sustain the fire in ITER

Negative ion sources are an excellent example for the manifold of applications of low temperature plasmas which ranges from basic research to industrial applications. One of the outstanding features is their usage in fusion research as negative hydrogen ion sources as a central component of the neutral beam injection systems for heating and current drive of the international fusion project ITER.

The fusion requirements initiated an ambitious development program for large and powerful negative hydrogen ion sources in Europe. The challenge to extract an ion current of 40 A from a low temperature hydrogen plasma at low pressure (0.3 Pa) is accompanied by the challenge to accelerate the beam to 1 MeV. Large RF sources with the size of a door operating at a power of up to 800 kW must deliver a uniform and stable negative hydrogen ion current density higher than 200 A/m² over the total area for one hour. Simultaneously, the amount of co-extracted electrons should be kept lower than one in order to avoid severe damages of the extraction system.

These requirements incorporate several challenges which can be met only by combining the disciplines of low temperature plasma physics, plasma surface interaction, ion beam optics, beam physics, and mechanical and electrical engineering. The state of the art and prospects of the negative hydrogen ion source development will be discussed with emphasis on the physical aspects.