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Large and powerful rf-driven hydrogen plasmas: negative ions for the heating systems of ITER

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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 application areas is in fusion, where a large and powerful negative hydrogen ion source is as a central component of the neutral beam injection systems for heating and current drive of the international fusion project ITER. The challenge to extract an ion current of 57 A (D) and 69 A (H) 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/m^2 over the total area for one hour. Simultaneously, the amount of co-extracted electrons should be kept below one in order to avoid severe damages of the extraction system. These requirements 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.