

Plasma physics in negative ion sources and challenges for MeV neutral beam injectors for fusion

Antonio Pimazzoni¹, E. Sartori^{1,2}, R. Casagrande¹, V. Candeloro¹, I. Mario¹,
R. Pasqualotto³, B. Pouradier-Duteil^{1,4}, A. Shepherd^{1,5}, D. Marcuzzi¹, NBTF team and
international contributors

¹ Consorzio RFX (CNR, ENEA, INFN, Università di Padova, Acciaierie Venete SpA),
Corso Stati Uniti 4 - 35127 Padova, Italy

² Università degli studi di Padova, Via VIII Febbraio, 2 - 35122 Padova, Italy

³ Consiglio Nazionale delle Ricerche, Istituto per la Scienza e la Tecnologia dei Plasmi, Corso
Stati Uniti, 4 - 35127 Padova, Italy

⁴ CEA, IRFM, F-13108 St Paul lez Durance, France

⁵ UKAEA (United Kingdom Atomic Energy Authority), Culham Science Centre, Abingdon,
Oxfordshire, OX14 3DB, United Kingdom of Great Britain and Northern Ireland

Neutral beam injectors are widely used to provide magnetically confined plasmas with additional heating, current drive and, in the case of medium size devices, torque. ITER will feature 2(3) heating neutral injectors (HNBs) delivering up to 16.7 MW of neutral H⁰/D⁰ with 870 keV/1 MeV energy. Neutralization of positive ion beams at 1 MeV is practically impossible so that the precursor of the neutral beam has to be a H⁻/D⁻ beam to be neutralized in a gas cell before reaching the ITER plasma. Such negative ions are electrostatically accelerated from an RF plasma source in which an hydrogen plasma is sustained by an inductively coupled discharge at 1 MHz. The generation of negative ions requires to properly tailor the plasma features by electric and magnetic fields and the evaporation of caesium in the ion source. Demonstrating the required performance for such injectors is the final goal of the Neutral Beam Test Facility (NBTF), hosted at Consorzio RFX (Padova, Italy) where a prototype of the HNB, named MITICA, is due to start operation in 2027. This work presents the main challenges in the operation of the negative ion source as well as the activities and future perspectives at the NBTF.

This work has been carried out within the framework of the ITER-RFX Neutral Beam Testing Facility (NBTF) Agreement and has received funding from the ITER Organization. The views and opinions expressed herein do not necessarily reflect those of the ITER Organization. This work has been carried out within the framework of the EUROfusion Consortium, funded by the European Union via the Euratom Research and Training Programme (Grant Agreement No. 101052200 — EUROfusion). Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or the European Commission. Neither the European Union nor the European Commission can be held responsible for them.