

Negative ion beam source physics as a complex system: identification of main processes and key interdependence

Friday 26 October 2018 08:30 (4 hours)

A key component of ITER is the heating Neutral Beam Injector (NBI) system, expected to be the main source of the input power necessary to reach fusion conditions. The nominal parameters of the ITER NBI (40 A negative H-/D- ion beam accelerated to 1 MeV and then neutralized) are so challenging that they require extensive international research and development activities. Reliable operation of NBI for one hour remains an open issue: it results from several processes, mutually interacting in a non-linear way.

In this contribution, complex network theory is applied to the physical processes (nodes) affecting generation, extraction and acceleration of negative ions in the simpler case of the NIO1 experiment, operating at Consorzio RFX. The number of driver nodes is 4; preferential matching identifies multiple sets of driver nodes. The most frequently identified driver nodes are interpreted as the most relevant processes: deflection of H- in the PG-EG gap depends on meniscus asymmetry, linked due to non-uniform ion flow in the plasma, as experimentally found; gas pressure in the vessel drives the compensation of the beam space charge, allowing the beam to propagate with no divergence increase. Evidence of the latter driver node spurred the investigation of the beam-generated plasma by means of a Retarding Field Energy Analyzer and numerical simulations.

Two surface phenomena will be discussed in the contribution, as they are very important for the NBI operation and must be included in the complex network. H- production is enhanced by evaporating cesium over the source wall material. The arrangement of the cesium atoms is correctly simulated by molecular dynamics: the resulting imperfect film is found to be affected by moderate temperature, which allows redistribution of cesium, whereas higher temperatures disorder again the film leading to evaporation. Another key role played by surfaces regards high voltage holding, for which a novel model, based on the assumption of a dielectric layer (oxidized metal), is proposed. When the dielectric strength of the layer is exceeded, quantum mechanical computations provide the current, which acts as a trigger for breakdown.

Country or International Organization

Italy

Paper Number

FIP/P7-40

Author: Dr ANTONI, Vanni (Consorzio RFX)

Co-authors: Dr DE LORENZI, Antonio (itRFX); Dr SARTORI, Emanuele (itRFX); Dr SPADA, Emanuele (itRFX); Dr SERIANNI, GIANLUIGI (ItRFX); Prof. CHITARIN, Giuseppe (itRFX); Dr CAVENAGO, Marco (INFN-LNL); Mr FERRON, Nicolo' Alvisè (itRFX); Dr VELTRI, Pierluigi (Consorzio RFX); Dr AGOSTINETTI, Piero (itRFX); Dr SUWEIS, Samir (Physics and Astronomy Dept. "G. Galilei"& CNISM, INFN, University of Padova, via Marzolo 8, 35131 Padova, Italy); Prof. LONGO, Savino (Dipartimento di Chimica, Università degli Studi "Aldo Moro", Bari)

Presenter: Dr ANTONI, Vanni (Consorzio RFX)

Session Classification: P7 Posters

Track Classification: FIP - Fusion Engineering, Integration and Power Plant Design