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Overview of Doppler shift spectroscopy Diagnostics Technique used in Neutral Beam Injectors - Challenges and Limitations

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Abstract

The Doppler Shift Spectroscopy (DSS) diagnostics, since its inception as a diagnostics technique in Neutral Beam Injectors (NBI), has proved to be an indispensable tool for characterizing positive and negative ion beams and optimising the ion sources performance [1-2]. For positive ion beams, beam parameters such as beam energy, beam species mix, beam impurity fractions, beam divergence and injected power fraction are routinely estimated using this technique [3-5]. In case of negative ion beams, this technique is primarily used to assess the beam inhomogeneity and beam stripping fractions which are very important parameters for understanding the negative ion source performance [2,6].

In positive ion beams, the ion source plasma discharge contains multi specie ions: H+,H2+ and H3+ which are accelerated to the same energy (E) during extraction of beam. During neutralization phase, they undergo variety of collisions such as charge exchange, dissociative charge exchange, dissociative ionization etc with the background H2 gas to form positive, neutral and negative ion species at different energies. Some of these species are also be formed in excited state , whose emissions are recorded and analysed in this technique. The beam or ion species mix is usually obtained from the ratios of the observed intensities corresponding to each energy group of excited neutrals which are correlated to various production processes via an extensive emission model. Similar technique are also used for DSS analysis of negative ion beams for the applications mentioned above. It may be noted that the present modelling efforts consider the uncertainties related to the available measured cross section database for both positive and fast negative ion beams.

Further in both positive and negative ion beams, the beam divergence is estimated using a rigorous line profile analysis [1,6-7]. In our recent study, it is observed that the conventional deconvolution techniques when applied to a low divergent large focal length beams (e.g. ITER-HNB/DNB , JET NBI etc.) yielded errors larger than 30%. A novel line profile method has been developed to account for such errors.

In this presentation, the details of a comprehensive collisional radiative modelling applicable to positive and negative ion beams and the line profile method developed for estimating divergence of low divergent large focal length beams are presented and discussed. The challenges and limitations of this technique are highlighted.

References

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