STUDY ON THE KEY TECHNOLOGIES INVOLVED IN THE LASER NEUTRALISATION OF NEGATIVE ION SOURCE

Hui-hui Hong [ab], Li-zhen Liang [a], Qian-xu Wang [ab], Bing Li [ab], Fang Wang [ab], Yuan-lai Xie [a*]
a Institute of Plasma Physics, Hefei Institutes of Physical Science, Chinese Academy of Sciences, Hefei, 230031, China
b University of Science and Technology of China, Hefei, 230026, China

Email:
huihui.hong@mail.ustc.edu.cn
laurrence@ipp.ac.cn(correspondingauthor)

Abstract

The conventional gas target scheme for magnetic confinement fusion neutral beam injection systems is inherently flawed, exhibiting deficiencies such as diminished charge exchange efficiency and residual gas interference. Conversely, the laser target has the theoretical capacity to attain a neutralisation efficiency exceeding 90%. In order to further increase the neutral beam injection power, improve the long-pulse operation capability and optimise the efficiency of the NNBI system, the paper proposes a systematic solution to the key challenges of laser neutralisation technology. The construction of a three-dimensional Monte Carlo model, coupled with a quantitative analysis of the competition mechanism between photon absorption and background gas in the interaction between the laser and the negative ion beam, has resulted in the establishment of a universal theoretical framework encompassing laser parameters, beam current characteristics and neutralisation probability. The experimental platform is to be designed with a modular architecture, integrating the anion source beamline system, the laser-particle beam dynamic coupling device and the multi-dimensional diagnostic unit. The coupling effects of wavelength selection, power stability and beam quality on the neutralisation process are systematically investigated, and the strategies of thermal effect suppression and precise mode frequency locking are developed. The study verifies the technical feasibility of laser neutralisation in complex environments, provides theoretical support and technical paradigm for the development of neutral beam systems with higher energy efficiency, and the research results are of great significance for the upgrading and transformation of neutral beams of fusion devices in China.

Key Words: Neutral beam injection(NNBI), Photodetachment, Negative beam source, High power laser, Optical enhancement cavity