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Conversion of a positive ion into a negative ion and a neutral atom: formation processes from a few keV to MeV energies

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High-power lasers are routinely used to generate energetic positively charged ions. In laser-plasma ion acceleration experiments negative ions and neutral atoms have been observed when energetic positive ions were passing through the spray of nanometer-sized water droplets. Beams of negative ions and neutral atoms have the same properties as beams of positive ions: energy, direction, and divergence of positive ions are preserved in the converted beam.

In the experiments conversion of hydrogen and carbon positive ions into their neutral atoms and negative ions with energies up to 140keV and 1.2MeV, respectively, is confirmed. However, the physics of charge exchange at high ion energies is not well understood. It is suggested that electrification of spray droplets plays a decisive role in these processes. We developed a multistage ion beam manipulation method to isolate the mechanism of charge exchange associated with the droplets electrification [1]. If the hypothesis of the role of electrically charged droplets in the production of negative ions confirmed, it opens new possibilities for controlling the electron capture process.

This paper also investigates the feasibility of using a liquid spray in a Neutral Beam Injection (NBI) system. We have shown that high neutralisation efficiencies can be achieved in the energy range 100keV to 1000keV. The requirements that NBI has to fulfil for different NBI functions on a DEMO or fusion power plant can be different [2]. E.g., the NBI to drive toroidal plasma rotation requires energies <100keV, but a pulsed tokamak [3] does not require high-energy NBI. A study-state current drive requires beam energies in the 1MeV range, for which for spray-based NBI further research is needed.

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