MeV Negative and Neutral atom beams

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The possibility of generating negative and neutral atoms with MeV energies would have an extraordinary interest for the number of applications in science and technology. Nowadays the role of negative and neutral atoms have increased substantially due to their essential in the fusion experiments for additional heating of the plasma based on the injection of powerful beams of neutral atoms into pre-heated plasma. The way to generate powerful neutral beams of fast atoms is to produce large amounts of either positive or negative ions, then to accelerate them and finally to neutralise the beam in the charge-exchange interactions with gas cloud. However, the efficiency is very low.

In the present paper we are demonstrating the efficient production of negative and neutral atom beams from laser produced MeV positive ions. In the processes of electron capture and loss during the interaction of energetic positive ion with the cold atoms the energy and momentum of the particle is preserved. Efficient generation of neutral hydrogen, carbon and oxygen atom beams along with their negative ions have been demonstrated [1, 2]. The process is rather general and different neutral atom beams can be generated.

We will discuss the physical aspects of this new finding and open problems. Although the electron capture and loss processes taking place when energetic positive ion interact with cold spray atoms can explain most of the observed features, the comprehensive analyses of the experimental data indicate a substantial difference between the existing data of the energy dependant cross sections of these processes and our measurements at high energies. At the moment we do not have clear explanation for that, but it suggests that the processes are more complex than the considered single electron capture and loss: for example, contribution of multiple electron capture or loss processes, the shell effects in the electronic structure of the projectile ion and/or target atoms may influence the probabilities of electron capture and loss in subsequent collisions. However, the process is highly efficient: in the equilibrium charge state distribution the numbers of positive and negative ions, and neutral atoms are almost the same.

Substantial work would be required for sophisticated model analyses in order to better understand the dynamics involved in the electron transfer processes. Until such a model is available, the present experiments open a possibility for measuring the cross sections of electron capture and loss processes to benchmark future theories.

[1] F. Abicht, et al., Applied Physics Letters **103**, 253501 (2013)
[2] M. Schnuerer, et al., Physics of Plasmas **20**, 1123105 (2013)