Electron screening in reaction between protons and lithium ions

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Due to Coulomb repulsion the cross section σ for charged particle induced nuclear reactions drops rapidly with decreasing beam energy. It is known that the cross section increases at low energies when the interacting nuclei are not bare, i.e. are in the form of atoms and molecules or in plasma [1]. The enhancement ratio could be written as

$$f(E) = \frac{\sigma(E+U_e)}{\sigma(E)},$$

where U_e is the screeening potential energy. It was recently observed by two independent groups that the cross section for fusion of two deuterons increases even more when deuterium is implanted into a metal [2,3]. A similar increase was subsequently observed in other nuclear reactions [4,5]. The cross section increase was attributed to metallic valence electrons, which may come closer to the deuteron and more effectively screen its charge than in a hydrogen atom. However, the size of the screening effect strongly depends on the host material and the reason for this dependence is not known. Raiola et al. [6] have observed a connection between U_e and the Hall coefficient of the metallic host, while Kasagi [2] suggested that U_e depends on deuterium concentration in the metal. We have studied the reaction $^{1}H(^{7}Li,\alpha)^{4}He$ in inverse kinematics, which simplified the experimental setup. The emitted α particles were measured in a silicon detector at a backward angle of 150°. The lithium ions delivered by the 2 MV Tandetron at Jožef Stefan Institute had energies between 0.34 and 4.3 MeV. We used 6 different targets from polymer Kapton to metallic Pd and various PdAg alloys. The PdAg alloys have a crystalline structure similar to Pd but their Hall coefficients differ considerably. Hydrogen was forced into the metallic targets by pressure gradient. Our preliminary results indicate that the U_e does not depend strongly on the Hall coefficient of PdAg alloys. The dependence on hydrogen concetration, however, is much stronger. We have observed large U_e values only in foils that contained less than a few percent of hydrogen per metallic atom.

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