Contribution ID: **38** Type: **not specified**

Electron screening in low-energy nuclear reactions

Thursday 15 June 2023 18:20 (20 minutes)

In nuclear reactions induced by low-energy charged particles, atomic electrons can participate in the process by screening the nuclear charge and so, effectively reduce the repulsive Coulomb barrier. Consequently, the measured cross section is enhanced by an effect called electron screening. In numerous experiments, different research groups [1-4] have reported extremely high values for the electron screening potential, much higher than the prediction based on an available theoretical model [5].

Nevertheless, even as a considerable amount of experimental data was collected over the past twenty years, a suitable theory, which can give an explanation of this effect, has not yet been found. However, electron screening is very important in nuclear astrophysics. For nucleosynthesis calculations, precise reaction rates should be known at very low energies where screening effects cannot be neglected and for a proper application, electron screening must be included in most calculations related to the nucleosynthesis of elements. However, this is impossible because we simply do not know enough about this effect. Furthermore, it is believed that electron screening in stellar plasmas differs from the laboratory screening because the atoms in the stellar interiors are in most cases in highly stripped states and the nuclei are immersed in a sea of almost free electrons, which tend to cluster closer to the nucleus than in atoms. The only thing that can be done at present is to try to better understand electron screening under the laboratory conditions and then to draw a parallel with the stellar plasma.

Lately, our group was focusing on studying the electron screening effect in palladium targets. The experimental study of the electron screening effect was performed using the 2˜MV Tandetron accelerator at Jo\v{z}ef Stefan Institute. We measured the ^{1}H(^{7}Li,α)^{4}He, ^{1}H(^{19}F,$\alpha\gamma$)^{16}O and ^{2}D(^{19}F,p)^{20}F reaction rates on two differently prepared hydrogen and deuterium containing palladium foils. In one of our targets we measured no screening, and in the second one we measured a high screening potential for all three reactions, that is an order of magnitude above the theoretical model. Contrary to the theoretical predictions, our research suggested that the reason behind this difference is linked to a dependence of electron screening potential on the host's crystal lattice structure and the location of the target nuclei in the metallic lattice.

The latest results from our research and an applied methodology will be presented.

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Session Classification: Photons and leptons

Track Classification: Nuclear reactions: Photons and leptons