Electron screening effect

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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 obtained extremely high values of electron screening, that are in several cases (depending on target-nuclei environment) more than an order of magnitude above the prediction based on available theoretical model in adiabatic limit.

Trying to understand this process, the effect of electron screening has been investigated by our group for already several years. We measured the highest value of electron screening in a graphite target. The measured value is about a factor of 50 above the adiabatic limit prediction and much higher than any potential measured so far. Further, our results pointed out that the Z dependence of the screening is even higher than Z^2 instead of expected linear dependence. This rules out the theory based on static electron densities. In order to explain our data, we proposed a new model assuming that an electron is caught in the attractive potential of the two approaching nuclei, similar to the potential of the hydrogen molecular ion. Most recently, we observed a new type of nuclear reaction supporting our model of electron screening process. Namely, we studied the proton induced nuclear fusion reaction on deuterium implanted in a graphite target, which normally produces a 3He nucleus and a γ-ray, but sometimes an electron can be emitted instead of a γ-ray. Up to now we observed such electrons only in a graphite target, but in order to confirm our findings under different experimental conditions, we plan to study this process with deuterium implanted in a titanium target. However, in order to keep the experiment under known conditions, we first have to understand electron screening in titanium. For this purpose we measured the ^{11}B(d,p)^{12}B, ^{16}O(d,p)^{17}O and ^{19}F(d,p)^{20}F reactions in inverse kinematics. Our latest results will be presented.