Investigation of the electron screening effect in deuteron fusion reactions under UHV conditions

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Observation of the enhanced screening effect in nuclear reactions has been experimentally confirmed by many research groups. However, a reliable comparison between experimental data and theoretical calculations is still ambiguous because of some systematic errors in experiments. One of the most important problems is the uncertainty resulting from oxidation of the target surface during the measurements. Here, we present results of the first ultra-high vacuum (UHV) experiment studying d+d nuclear reactions in a deuterized Zr target for which the experimental discrepancies are especially large. The total cross sections and angular distributions of the $^2\text{H}(d,p)^3\text{H}$ and $^2\text{H}(d,n)^3\text{He}$ reactions have been measured using a deuteron beam of energies between 8 and 30 keV provided by the electron cyclotron ion source with an excellent long term stability. The atomic cleanliness of the target surface has been assured by combining Ar sputtering of the target and Auger spectroscopy. The determined screening energy for Zr of $(497\pm7)$ eV is much larger than the value $(298\pm8)$ eV obtained in the previous high vacuum experiment, confirming advantages of the new experimental method. A possible theoretical explanation of the enhanced screening effect will be discussed.