New measurement of screening potential by 'cooperative colliding process' for the d+d reaction in metallic electron environment

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Screening for nuclear reactions in metal plays an important role to understand the mechanism of the cold fusion. Although large values of the screening potential were reported in deuteron beam experiments for various metals, the experiments so far performed are not faultless but possibly bring large systematic errors due to uncertainties of target deuteron density. Having performed a series of low-energy deuteron beam experiments to explore enhanced nuclear reactions in various environments, we found a new reaction process which ensures to determine the screening potential much more accurately. The process is unique to the molecular beam and was found as a strange d+d reaction induced by D_3^+ molecular beams in liquid Indium: we call it 'cooperative colliding d+d reaction'.

Experimental setups were almost same as reported in [1]. Solid and liquid In were bombarded by D_3^+ beams from 15 to 60 keV (E_d = 5~20 keV). For the liquid, the metal In was liquefied by heating up above the melting point (156.6°C). Protons and tritons from the d(d,p)t reaction were measured by a Si detector with the energy resolution of about 20 keV.

The following results are characteristics of the cooperative colliding d+d reaction observed in liquid In: ①Energy spectra are quite odd. Such an example of proton spectra is shown in Fig. 1 with solid circles. The shape is very broad and is largely skewed. Moreover, the peak position shifts to higher energy than that of the normal spectrum (shown by an arrow). ②An excitation function of the yield cannot be explained by the thick target yield of the d(d,p)t reaction. The yield for the liquid In decreases much slower with decrease of incident energy than the normal thick target yield. ③ When bombarded by an atomic D^+ beam, the yield of the d+d reaction diminishes, at least less than 1/70 of that by the D_3^+ beam.

In the cooperative colliding reaction, two deuterons in a molecule play an essential role as shown schematically in Fig. 2: one deuteron in a molecule is elastically scattered by In, and, then, it collides with the other to cause the d(d,p)t reaction. Since the reaction occurs with the partner in the molecule, a trajectory (the initial position and the collision point) is inevitably determined. The solid curve in Fig. 1 is a proton spectrum calculated by the cooperative colliding mechanism with simple assumptions for the D_3 molecule. The calculation reproduces well not only the energy spectra, but also the excitation function. Detailed analyses will bring accurate information on the screening potential between deuterons surrounded by conduction electrons.

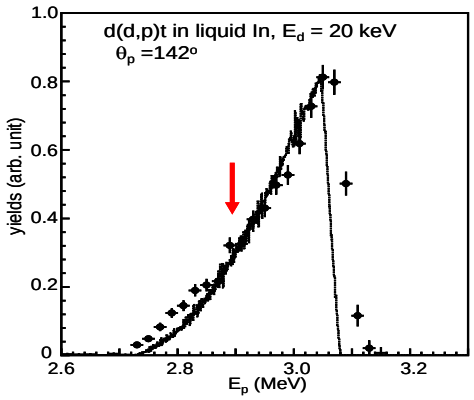

Figure 1: *Proton spectrum measured at θ = 142°.*
An arrow shows the peak position of protons emitted from the normal d(d,p)t reaction.

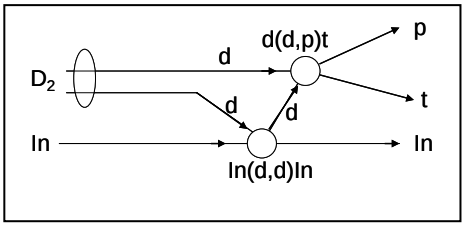

Figure 2: *Cooperative colliding reaction.*

[1] Y. Toriyabe et al., Phys. Rev. C85, 054620 (2012).