Search for the Radiative Capture Reaction $d + d \to^4 He + \gamma$ from the $dd\mu$ Muonic Molecule State

L.N. Bogdanova[a], V.R. Bom[b], D.L. Demin[c], C.W.E. van Eijk[b], V.V. Filchenkov[c], N.N. Grafov[c], V.G. Grebinnik[c], K.I. Gritsaj[c], A.D. Konin[c], A.V. Kuryakin[d], V.A. Nazarov[d], V.V. Perevozchikov[d], A.I. Rudenko[c], S.M. Sadetsky[e], Yu.I. Vinogradov[d] A.A. Yukhimchuk[d], S.A. Yukhimchuk[c], V.G. Zinov[c], S.V. Zlatoustovskii[d]

[a] *Institute of Theoretical and Experimental Physics (ITEP), Moscow, 117218, Russia*
[b] *Delft University of Technology, 2629 JB Delft, the Netherlands*
[c] *Joint Institute for Nuclear Research (JINR), Dubna, 141980, Russia*
[d] *Russian Federal Nuclear Center, All-Russian Research Institute of Experimental Physics (RFNC-VNIIEF), Sarov, Nizhny Novgorod reg., 607200, Russia*
[e] *St.-Petersburg Nuclear Physics Institute (PNPI), Gatchina, 188350, Russia*

Reaction $d + d \to^4 He + \gamma + 23.8$ MeV is involved in both primordial and stellar nucleosynthesis, it gives a valuable information about d and ^4He properties. Existence of the p-wave strength in $^2H(\vec{d}, \gamma)^4He$ reaction (according to [1], over 50% of the cross section strength at energies below 80 keV is due to E1 and M2 p-wave capture) might affect the low energy behavior of the S-function. A direct way to observe this p-wave manifestation is a muon catalyzed fusion (μCF) from the bound $J = 1$ states of $dd\mu$ muonic molecule that correspond to the relative orbital angular momentum of nuclei $L = 1$ and practically zero energy. Charge-symmetric reactions $d(d,n)^3He$ and $d(d,p)^3H$ were successfully studied by μCF method [2]. A p-wave reaction strength ratio measured in μCF experiment $R_p(n/p) = 1.42 \pm 0.03$ [3] agreed with the value deduced from the low energy $\vec{d}d$ data [4] and confirmed essential suppression of the proton branch.
A search for the reaction $dd\mu \to^4 He + \mu + \gamma$ was performed using the experimental μCF installation TRITON [5] and $NaI(Tl)$ detectors for γ-quanta. The high pressure target filled with deuterium at temperatures 85÷800 K was exposed to the μ^- beam of the JINR phasotron to detect γ-quanta of 23.8 MeV energy. At temperatures $T > 150$ K $dd\mu$ molecules are formed in a resonance process in J=1 state, hence, being detected, 23.8 MeV γ-quanta would unambiguously indicate a finite p-wave contribution to radiative capture rate. Analysis of the data collected in runs with protium admixture allowed determining the correlated background and efficiency of γ detection. The first experimental estimation for the yield of the radiative deuteron capture from the $dd\mu$ state J=1 was obtained at the level $n_\gamma \leq 2 \times 10^{-5}$ per one fusion. Results will be presented [6] and future plans for the experiment to reach the needed sensitivity ($\leq 10^{-6}$) will be discussed.

References

[1] L.H. Kramer *et al.*, Phys.Lett. **B304** (1993) 208.
[2] L.N.Bogdanova *et al.*, Phys.Lett. **B115** (1982) 171.
[3] D.V.Balin *et al.*, Phys.Lett. **B141** (1984) 173, JETP Lett. **40** (1984) 112, Muon Cat. Fusion **1** (1987) 127.
[4] B.P. Ad'yasevich, V.G. Antonenko, V.E. Bragin, Phys.At.Nucl. **33** (1981) 619.
[5] Yu.P. Averin *et al.*, Hyperfine Interactions **118** (1999) 111.
[6] L.N. Bogdanova *et al.*, nucl-ex/0203005.