§18. Hyperspherical Calculations of Low-Energy Rearrangement Processes in $dt\mu$

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The results of accurate hyperspherical calculations of the reaction

$$d\mu(n_i) + t \rightarrow t\mu(n_f) + d \qquad (1)$$

between states of the n_i=n_f=1 and n_i=n_f=2 manifolds for zero total angular momentum of the collision system are reported. The muon transfer probability for n_i=n_f=1 is shown in Fig.1.

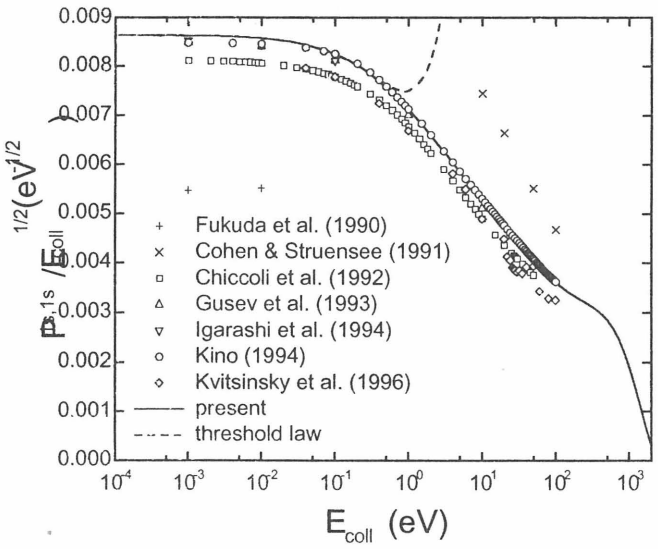

Fig.1. Comparison of different calculations of reaction (1) between the n_i=n_f=1 states. $P_{1s,1s}$ is the reaction probability, E_{coll}=E-$E_{d\mu\ (n=1)}$ is the collision energy in the initial state.

A new parameterization of the threshold behavior of the cross section of this reaction in the spirit of the effective range theory is derived:

$$\sigma_{fi} = \frac{4\pi|a''|}{k}\left[1 - 2|a''|k + \frac{4}{3}\beta k^2 \ln k + O(k^2)\right] \qquad (2)$$

where β=$m_{t,d\mu}\alpha$, $m_{t,d\mu}$ is the reduced mass of t and $d\mu$, and α is the electric polarizability of $d\mu(n$=1).

The muon transfer probability for n_i=n_f=2 is shown in Fig.2. This process, to our knowledge, has not yet been considered in literature.

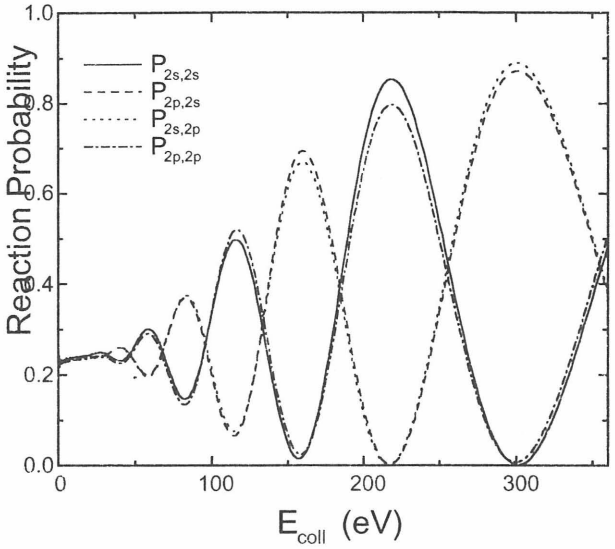

Fig.2. $P_{1s,1s}$ is the probability of reaction (1) between the n_i=n_f=2 states, E_{coll}=E-$E_{d\mu\ (n=1)}$ is the collision energy in the initial state.

The calculations reported here reveal the following qualitative features of reaction (1): (i) The reaction between n_i=n_f=1 states is suppressed as compared to that between n_i=n_f=2 states: the maximum probability of the former is about 0.07 while that of the latter is close to 1; (ii) The probabilities P_{if} of reactions between n_i=n_f=2 states oscillate as functions of energy; (iii) There is an approximate degeneracy: $P_{2s,2s}$ is close to $P_{2p,2p}$ and $P_{2s,2p}$ is close to $P_{2p,2s}$. These features result from interference effects in the reaction dynamics and can be explained in terms of semiclassical theory or by a model analysis. Besides the numerical results we presented an analysis of the threshold behavior of the reaction between ground states. Equation (2) giving an analytical expression for the reaction cross section in terms of a single parameter $|a''|$ yields a good accuracy in the most interesting energy range for applications E_{coll} < 1 eV and can be used in muon-catalyzed fusion kinetics calculations. Upon appropriate redefinition of β, this equation applies to a wide class of rearrangement reactions in collisions between a charged particle and a neutral polarizable target having no permanent dipole and quadrupole moments.

Reference:
[1] O.I.Tolstikhin and C.Namba.; Phys. Rev. A. **60**, 5111-4 (1999)