This work on this brief report was done within the project N96-02-18897 of the Russian Foundation for Fundamental Research.

REFERENCES

1. *Veltman M.* The Higgs System. In: Perspectives in Higgs Physics, Ed. G.L.Kane, World Scientific, Singapore. 1993. P.1-45; Instituut-Lorenz report N°0601, Leiden. 1989.
2. *Gunion J.F., Haber H.E., Kane G.L., Dawson S.* The Higgs Hunter's Guide, Addison-Wesley Publishing Co. 1990.
3. *Haber H.E.* Invited talk at the Int. Europhysics Conf. on High Energy Physics, 1995, Brussels, CERN-TH/96-07. 1996; *Djouadi A., Spira M., Zerwas P.M.* Preprint DESY 95-210. 1995; *Kniehl B.A.* //Int.J.Mod.Phys., 1994. **A10**. 443.
4. *Braaten E., Leveille J.P.* //Phys.Rev., 1980. **D22**. 715; *Drees M., Hikasa K.* //Phys.Rev., 1990. **D41**. 1547; //Phys.Lett., 1990. **B240**. 455; ibid. 1991. **B262**. 497 (E).
5. *Gorishny S.G., Kataev A.L., Larin S.A.* //Sov.J.Nucl.Phys., 1984. **40**. 329.
6. *Gorishny S.G., Kataev A.L., S.A.Larin S.A., Surguladze L.R.* //Mod.Phys.Lett., 1990. **A5**. 2703; //Phys.Rev., 1991. **D43**. 1633.
7. *Kleiss R., Kunszt Z., Stirling W.J.* //Phys.Lett., 1991. **B253**. 269.
8. *Gray N., Broadhurst D.J., Grafe W., Schilcher K.* //Z.Phys., 1990. **C48**. 673.
9. *A.L.Kataev A.L., Kim V.T.* ENSLAPP-A-407/92, Annecy. 1992).
10. *Kataev A.L., Kim V.T.* In: Proc. III Int. Workshop on Software Engineering, Artificial Intelligence and Expert Systems in High Energy and Nuclear Physics, October 1993, Oberammergau, Germany, Eds. K.-H.Becks and D.Perret-Gallix, World Scientific, Singapore. 1994. P.623-637.
11. *Kataev A.L., V.T.Kim V.T.* //Mod.Phys.Lett., 1994. **A9**. 1309.
12. *Kataev A.L.* //Phys.Lett., 1992. **B287**. 209.
13. *Djouadi A., Spira M., Zerwas P.M.* //Phys.Lett., 1991. **B264**. 440.
14. *Surguladze L.R.* //Phys. Lett., 1994. **B341**. 61.
15. *Chetyrkin K.G., Kwiatkowski A.* LBL-37269, Berkeley. 1995.
16. *Larin S.A., van Ritbergen T., Vermaseren J.A.M.* //Phys. Lett., 1995. **B362**. 134.

KINETICS OF EXCITED MUONIC HYDROGEN

W. Czaplinski[1)], A. Gula[1)], A. Kravtsov, A. Mikhailov, N. Popov[2)]

[1)] *Institute of Physics and Nuclear Technique, Krakow*
[2)] *München University, München*

1. One of the crucial characteristics of the muon catalyzed fusion in the deuterium-tritium mixture, which determines the efficiency of the synthesis, is a ground state population of muonic deuterium, q_{1S}. Soon after the first calculations were made for the q_{1S} value [1] it

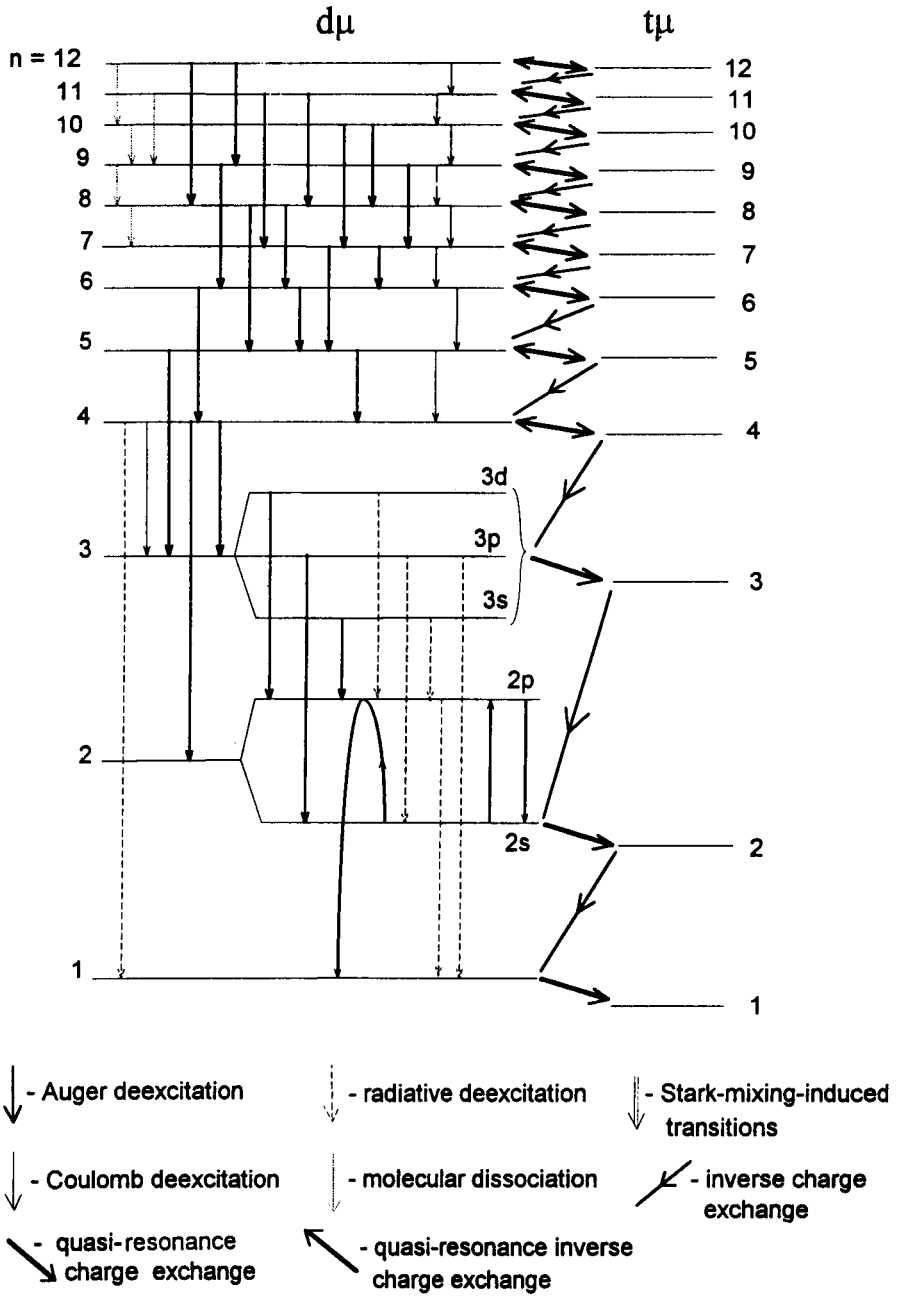

Fig.1. Scheme of $d\mu$ atom deexcitation and muon transfer processes in the collision with tritium

[2]. The experiment revealed rather large q_{1S} values for high tritium concentrations, which could not be reproduced by the theory for many years.

In the present paper we consider the cascade scheme (Fig.1) taking into account that the isotope exchange reactions which were considered earlier as irreversible actually are not. It is known from a number of experiments that excited muonic atoms are not thermalized [3], being accelerated during deexcitation process. As a matter of fact, if muonic atoms have energy higher than the resonance defect $\Delta u = (\mu_2 - \mu_1)/2n^2$ ($48/n^2 eV$ for D-T mixture), the isotope exchange reaction is reversible. This fact decreases effectively the charge exchange rate for a given n. Let us $N(d \to t)$ and$N(t \to d)$ be the numbers of the corresponding muon transfers (in a unit of time and unit of volume). Then

$$N(d \to t) = \lambda(d \to t)\phi c_t N_{d\mu}$$

$$N(t \to d) = \lambda(t \to d)\phi c_d N_{t\mu},$$

where $N_{d\mu}$ are $N_{t\mu}$ densities of $d\mu-$ and $t\mu-$atoms in the state in question n. Since Coulomb capture rates of muon by deuterium and tritium are equal, the following equation is satisfied:

$$c_t N_{d\mu} = c_d N_{t\mu}. \qquad (1)$$

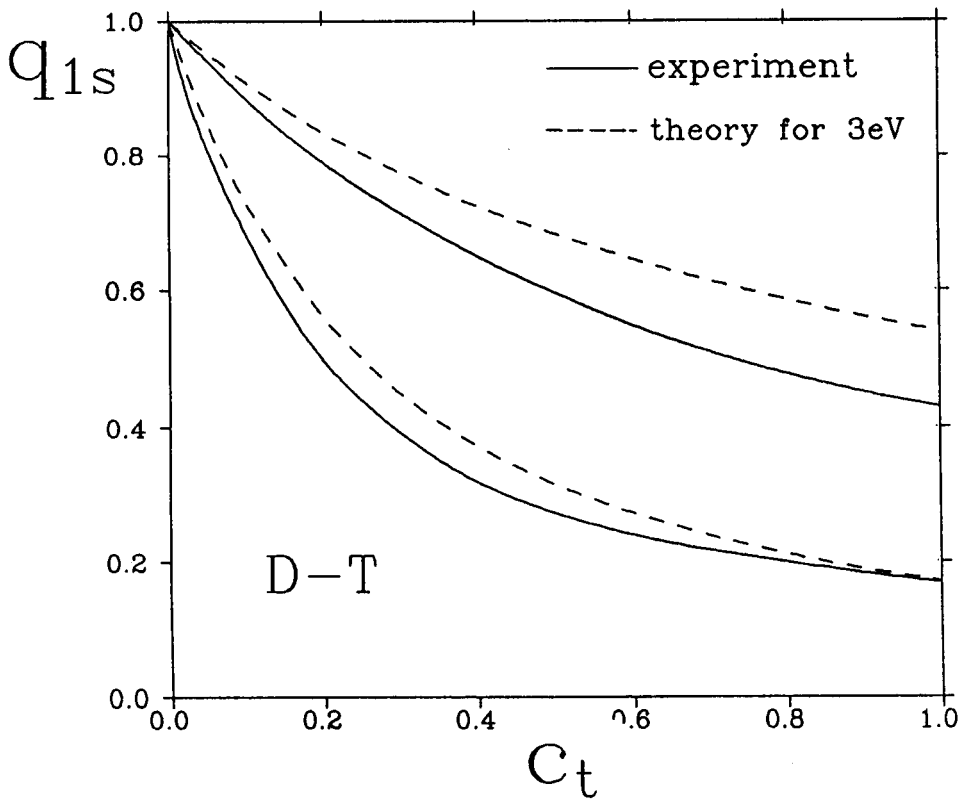

Fig.2. Comparison of experimental data on q_{1S} [2] (solid lines) for the D-T mixture with theoretical ones (dashed lines), calculated for $\phi = 0.1$ (upper curve) and 1.2 (lower curve), liquid hydrogen density and $E = 3$ eV

Then the change of the number of muonic deuterium atoms, caused by the quasiresonant charge exchange, is determined by the difference of the corresponding rates:

$$N(d \to t) - N(t \to d) = [\lambda(d \to t) - \lambda(t \to d)]\phi c_t N_{d\mu}.$$

While the collision energy is higher than the resonance defect, the rates of the direct and inverse charge exchange are almost equal, so these processes practically do not influence the population of the higher levels $n > \tilde{n}$ and may be neglected in principle. For $n \leq \tilde{n}$ the resonance defect is higher than the collision energy and inverse charge exchange is forbidden, which makes eq.(1) invalid.

Calculating q_{1S} values, we used the rates of isotope exchange and Coulomb deexcitation calculated earlier [4]. The obtained q_{1S}-values for collision energy 3 eV are shown in Fig.2 together with the experimental ones. It is seen that experimental data on q_{1S} parameter can be explained by a large collision energy of muonic atoms.

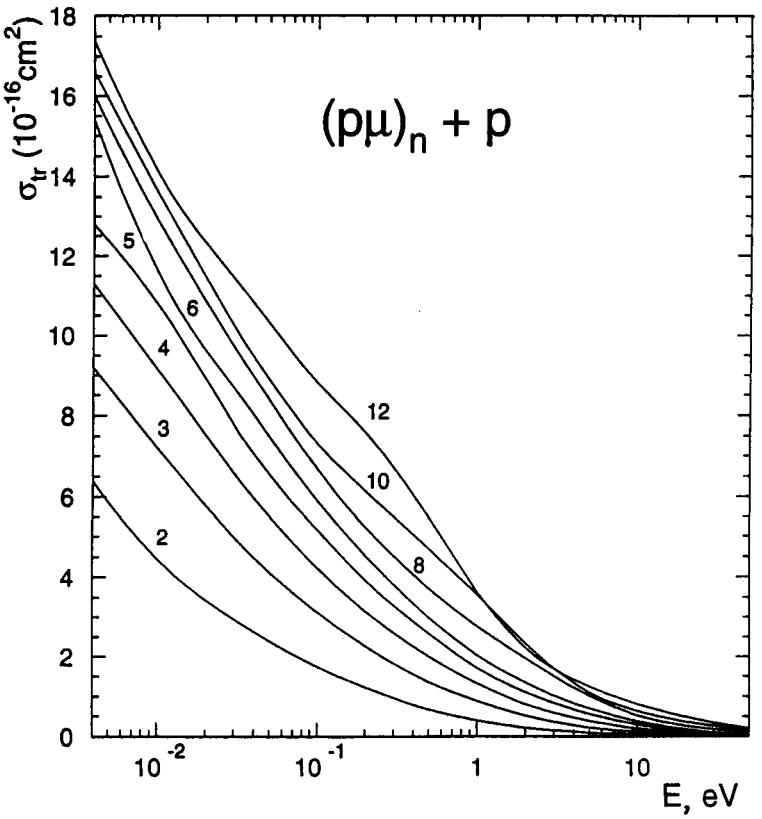

Fig.3. Transport cross sections for $(p\mu)_n^* + p$ scattering

2. The important characteristics of the muonic atom kinetics, which determines the slowing down of the muonic atom, is the transport cross section

$$\sigma_{tr} = \int (1 - \cos\theta) d\sigma_{el}.$$

We used a classical formula

$$\sigma_{tr} = \pi \int_0^\infty [1 - \cos\theta(\rho)] d\rho^2,$$

where $\theta(\rho)$ is the scattering angle of muonic atom at a given impact parameter ρ.
The deflection angle is given by

$$\Theta(\rho) = \pi - 2\rho \int_{r_t}^\infty \frac{dr}{r^2\sqrt{1 - u(r)/E - \rho^2/r^2}},$$

where r_t is the turning point for given energy E and effective potential $u(r)$. The deflection angle ranges from 0 to π for repulsive terms and from -∞ to π for attractive and compound terms. The deflection angle $\Theta(\rho)$ and the scattering angle $\theta(\rho)$, which, by definition, always lies between zero and π, have to be connected by

$$\Theta(\rho) = q\theta(\rho) - 2\pi\nu,$$

where $q = \pm 1$ and ν is a non-negative integer. For a given $\Theta(\rho)$ the numbers q and ν are chosen so that $\theta(\rho)$ lies between zero and π. The deflection angle $\Theta(\rho)$ has been calculated for every term (n, n_1, n_2, m). The obtained transport cross sections, given in Fig.3, correspond to large thermalization rates of muonic hydrogen.

REFERENCES

1. *Menshikov L.I., Ponomarev L.I.* //Pis'ma ZhETF. 1984. **39**. 542.
2. *Ackerbauer P. et al.,* Proceedings of International Workshop on LEMS'93, ed. M.Leon, Los Alamos Laboratory Report No. LA-12698-C. 1994. P.285.
3. *Crawford J.F. et al.,* //Phys.Rev., 1991. **D43**. 46.
4. *Czaplinski W. et al.,* //Phys.Rev., 1994. **A50**. 525.