# FORMATION OF HYDROGEN MESIC MOLECULES AT MODERATE GAS DENSITY

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The high formation rate of the $dt\mu$ molecules in the reaction $t\mu + D_2 \rightarrow [(dt\mu)dee]$ predicted theoretically /1/ and demonstrated experimentally /2—3/ makes it possible to raise the question of the practical use of muon catalysis /4/. However, available experimental data concern only sufficiently dense DT mixture with density not far from the density of liquid hydrogen. Only this region of densities is interesting for practical applications. On the other hand the cross section of mesic molecule formation is calculated reliably only in the case when one neglects the effects of environment i. e. at zero density of the gas /5/.

It is well-known that mesomolecules form owing to the resonant mechanism /6/ and the energies and decay widths $\Gamma_v$ of resonances are very small (especially in the case of the dd$\mu$ mesomolecule). As a result the effects of environment become considerable for low densities of the medium. This leads to a complicated nonlinear dependence of the mesomolecular formation rate $\lambda_{dt\mu}$ on the density $\Phi$ (in units of the density of liquid hydrogen $N_0$). In ref /6/ we study these effects considering the ideal gas of $D_2$ molecules surrounding the mesomolecule and in leading approximation in the density. The formation rate is:

$$\lambda_{dt\mu} = N_0 \int \sigma_{dt\mu}(E)\, f(E)\, V_{c.m.}\, dE.$$

$$\sigma_{dt\mu} \cdot V_{c.m.} = \sum_{K_i, K_f} n(K_i)\, |V|^2_{K_i \to K_f}\, I(E).$$

Here f(E) is a distribution of $D_2$+t$\mu$ in energies; $|V|^2$ is the transition matrix element calculated in Ref. /5/; I(E) is a resonance form which is described by the Breit-Wigner formula with finite width /8/:

$$I(E) = (\Gamma_v + \Gamma_{coll}) / [(E - E_{res} + \Delta)^2 + \tfrac{1}{4}(\Gamma_v + \Gamma_{coll})^2]\, 2\pi.$$

Here $\Delta$ is the shift of resonance energy due to environment and $\Gamma_{coll}$ is the collision width. As shown in ref /6/ in linear approximation in gas density, values of $\Delta$ and $\Gamma_{coll}$ are concerned with real and imaginary parts of the amplitude of scattering $D_2$ on mesomolecular complex outside the mass shell (if the energy of $D_2$+t$\mu$ does not coincide with the resonance energy). If interaction between $D_2$ and the complex is approximated by a hard core potential with radius R then:

$$\Gamma_{coll} = 4\pi R^2 \frac{\Phi N_0}{2} \sqrt{\frac{2\lambda}{m}}, \quad \Delta(\lambda) = \frac{4\pi}{3} R^3 \frac{\Phi N_0}{2} \lambda.$$

Here $\lambda = E - E_{res}$ is distance to resonance, m is the reduced mass of $D_2$ and the complex. For small temperatures T the main contribution to mesomolecular formation comes from the transition $0 \to 1$ with a negative energy of the resonance /5/, (the collision width for positive resonances vanishes and their contribution is negligible) and $|E_{res}| >> T$. Substituting for R value R=2.9 Å (which reproduces the cross section of elastic scattering $D_2$ on $D_2$) we obtain:

$$\Gamma_{coll} = 4.1\, \Phi \sqrt{|E_{res.}| / 1\ mev} = 18.6\ mev\ \Phi; \quad \Delta = -2.2\, E_{res.} \cdot \Phi.$$

When density increases, $\lambda_{dt\mu}$ starts to grow too (owing to the increase of the collision width) and then at $\Phi \sim 0.2$ it bends as the resonance goes further away from zero energy. Qualitatively this behaviour coincides with experimental data /9/.

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