Dissociative recombination of D3O+ and H3O+: absolute cross sections and branching ratios.

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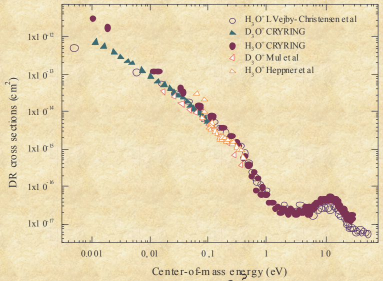
Energetically opened channels :

at 0 eV center-of-mass energy

$$X_3O^+ + e \rightarrow \begin{cases} X_2O + X + 6.4eV & (\alpha) \\ OX + X_2 + 5.7eV & (\beta) \\ OX + X + X + 1.3eV & (\chi) \\ O + X_2 + X + 1.4eV & (\delta) \end{cases} \quad X = (H, D)$$

Results

Cross sections



Small isotope effect :

DR H_3O^+ more efficient than that for D_3O^+

References:

P. M. Mul, J. Wm.McGowan, P. Defrance and J. B. A. Mitchell, J. Phys. B, **16**, 3099-3107 (1983)

L. Vejby-Christensen, L.H. Andersen, O. Heber, D. Kella, H. B. Pedersen, H. T. Schmidt and D. Zajman, Astrophys. J., **483**, 531-540 (1997)

R. A. Heppner, F. L. Walls, W. T. Armstrong and G. H. Dunn, Phys. Rev. A, **13**, 1000-1011 (1976)

Branching ratios

<u>For H_3O^+</u>

$n_\alpha(H_2O + H) = 0,18 \pm 0,05$

$n_\beta(OH + H_2) = 0,11 \pm 0,05$

$n_\chi(OH + H + H) = 0,67 \pm 0,06$

$n_\delta(O + H_2 + H) = 0,04 \pm 0,06$

at $E_{CM} = 0eV$

<u>For D_3O^+</u>

$n_\alpha(D_2O + D) = 0,17 \pm 0,05$

$n_\beta(OD + D_2) = 0,13 \pm 0,03$

$n_\chi(OD + D + D) = 0,70 \pm 0,06$

$n_\delta(O + D_2 + D) = 0,00 \pm 0,04$

at $E_{CM} = 0eV- 0,005eV$

Three-body break-up dominance

and

No isotop effect

For comparison !

DR of H_3O+ (Astrid, Denmark):

$n_\alpha(H_2O + H) = 0,33 \pm 0,08$

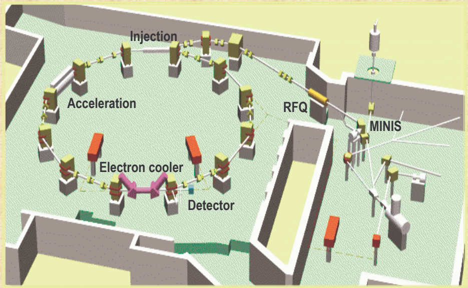
$n_\beta(OH + H_2) = 0,18 \pm 0,07$

$n_\chi(OH + H + H) = 0,48 \pm 0,08$

$n_\delta(O + H_2 + H) = 0,01 \pm 0,04$

at $E_{CM} = 0eV$

Data acquisition & analysis



Cross sections

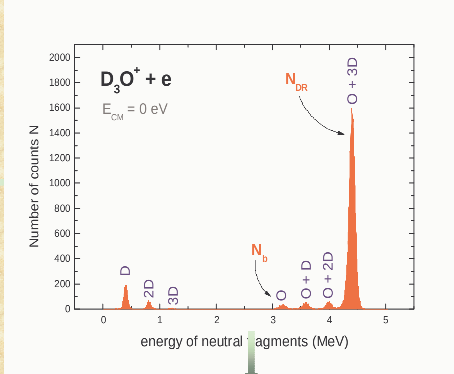
Surface barrier detector → MCA

- MCA : MultiChannel Analyser
- Destruction rate per ion per unit time :

$$R_b = \frac{dN_b}{dt}\frac{v_i}{c}e\frac{1}{I_i}$$

- c : circumference of the ring
- l : length of the electron cooler
- I_i : ion current
- v_i : ion velocity
- n_e: electron density
- Electron velocity distribution :

$$f(v_e) = \frac{m_e}{2\pi kT_{e\perp}}\left(\frac{m_e}{2\pi kT_{e\parallel}}\right)^{1/2}\exp\left(-\frac{m_e v_{e\perp}^2}{2kT_{e\perp}} - \frac{m_e v_{e\parallel}^2}{2kT_{e\parallel}}\right)$$



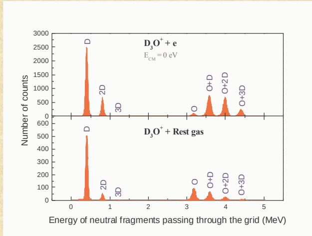
$$< v\sigma >= R_b \frac{c}{n_e l}\frac{N_{DR}}{N_b}$$

σ:

$$< v_{cm}\sigma >= \int_{-\infty}^{+\infty} v\sigma(v) f(v_{cm}, v_e) dv$$

Branching ratios

Surface barrier detector + GRID → MCA →



Number of counts coming from DR events

Number of dissociations in the corresponding channels (α, β, χ, δ)

$$\begin{pmatrix} N(O+3D) \\ N(O+2D) \\ N(O+D) \\ N(O) \\ N(3D) \\ N(2D) \\ N(D) \end{pmatrix} = \begin{pmatrix} T^2 & T^2 & T^3 & T^3 \\ T(1-T) & 0 & 2T^2(1-T) & T^2(1-T) \\ 0 & T(1-T) & T(1-T)^2 & T^2(1-T) \\ 0 & 0 & 0 & T(1-T)^2 \\ 0 & 0 & 0 & T^2(1-T) \\ 0 & T(1-T) & T^2(1-T) & T(1-T)^2 \\ T(1-T) & 0 & 2T(1-T)^2 & T(1-T)^2 \end{pmatrix} * \begin{pmatrix} N_\alpha \\ N_\beta \\ N_\chi \\ N_\delta \end{pmatrix}$$

T = 0.312, transmission of the grid

Branching ratios :

$$n_i = \frac{N_i}{\sum_i N_i} \quad with \quad i = \alpha, \beta, \chi, \delta$$