LEXFOR "Thermonuclear reaction rate"

(N. Otsuka and O. Schwerer, 2018-04-09, Memo CP-D/956)

LEXFOR "Thermonuclear reaction rate" was updated after approval of the proposal submitted in Memo CP-D/810. During discussion on C2277.005 in PRELIM.C173, we found that the LEXFOR entry must be further improved (*e.g.*, mistake in equation, reaction rates not for EXFOR compilation). This LEXFOR entry is rewritten as appended to this memo.

C2090.008.1 and C2277.005.1 provide the direct interaction portion of the reaction rate from their measurements, which is complemented by the resonance portion of the reaction rate from the literature to form the total reaction rate, and we propose a new quantity code DI,SGV in this memo.

C2090.008.2 provides the resonance portion of the reaction rate determined from the literature, and it must be coded under the data heading MISC instead of DATA.

We propose to add "Thermonuclear" in the expansion the parameter and quantity codes to clarify that only thermonuclear reaction rates are for EXFOR compilation. At the same time, we also propose to delete "(sigma*velocity)" from the expansion because it could be misleading.

Dictionary 32 (Parameters)

SGV Thermonuclear reaction rate ~~(sigma*velocity)~~

Dictionary 236 (Quantities)

,SGV Thermonuclear reaction rate ~~(sigma*velocity)~~
~~Spectrum-averaged, always used with the modifier 'MXW'~~

DI,SGV Thermonuclear reaction rate, direct reaction portion

We checked all data coded with SGV and CM3/SEC. We observe centres converted the original data in cm^3/sec/mol to those in cm^3/sec in many cases. We request retransmission of the affected entries summarized below after restoring the original data tabulated by the authors with CM3/S/MOL. REACTION SF8=MXW must be also deleted (except for C0484).

Entry	Subentry	Remark
A0090	003	Use the unit code K9 for the temperature.
A0653	014-017	Use the unit code K9 for the temperature.
A0654	017-020	Use the unit code K9 for the temperature.
C0484	006-009	Unit must be changed but numbers should be kept. Delete DERIV.
F0042	003	
F0311	004-005	Original data are in cm3/g/sec. The original data could be restored with ARB-UNITS and SF8=REL.
F0323	006-007	
F0421	004	

Appendix: Revised LEXFOR entry "Thermonuclear Reaction Rate"

Thermonuclear Reaction Rate

Definition

The thermonuclear reaction rate (often denoted by$<\sigma\cdot v>$ symbolically) is at temperature T is defined by

$$<\sigma\cdot v> = \int \sigma(v)\, v \exp(-\mu v^2/2kT)\, v^2\, dv \,/\, \int \exp(-\mu v^2/2kT)\, v^2\, dv$$

$$= (2/\mu)^{1/2} \int E\, \sigma(E) \exp(-E/kT)\, dE \,/\, \int E^{1/2} \exp(-E/kT)\, dE,$$

where v is the relative velocity between the projectile and target, E is the centre-of-mass energy, k is the Boltzmann constant, μ is the reduced mass of the projectile and target. In astrophysics application it is often multiplied by the Avogadro constant.

REACTION Coding: SGV in SF6.

Units: a code from Dictionary 25 with the dimension B*V (*e.g.*, CM3/SEC/MOL).

The spectrum average modifier MXW is always omitted by definition of the quantity. The data type DERIV is also always omitted because typically the cross section from the measurement must be extrapolated to the energy not covered by the experiment (*e.g.*, by using a reaction model) to perform the energy integration. However, the derivation of the reaction rate must be always explained under the keyword ANALYSIS.

The compiler may indicate existence of the reaction rate data by RRATE under the keyword ADD-RES without their compilation.

If the authors provide a portion of the reaction rate corresponding to a specific reaction mechanism determined in their measurement, it can be compiled separately with the branch code DI.

Example

(…(P,G)…,DI,SGV) Direct interaction portion of the proton capture reaction rate.

The thermonuclear reaction rate is coded with the projectile temperature under data headings such as KT and KT-K.

Note:

- The quantity $<\sigma\cdot v>/v_T$ with the thermal velocity $v_T=(2kT/\mu)^{1/2}$ is known as the Maxwellian-averaged cross section (,SIG,,MXW).
- The thermonuclear reaction rate can be generalized to any velocity distribution n(v) and φ(v) = v n(v) such as $R= \int \varphi(v)\sigma(v)\, dv \,/\, \int n(v)\, dv$. Also the number of products per time per volume $N_b \cdot N_t \cdot R$ (N_b: number of projectiles per volume, N_t: number of target atoms per volume) is referred to as the reaction rate. However the reaction rates other than the thermonuclear reaction rates are not characterized by temperature, and *not* compiled in

EXFOR in general. When necessary, its existence may be mentioned with the code RRAC under the keyword ADD-RES.