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DATE: June 7, 1996
TO: Distribution
FROM: V. McLane, S. Dunayeva
SUBJECT: Astrophysical s-factor

We wish to propose to add the following codes for the compilation of astrophysical s-factors. Accompanying LEXFOR entries are attached.

Dictionary 32

SFN s-factor

Dictionary 36

`,SGV,,SFN` s-factor for reactivity
`,SIG,,SFN` s-factor for cross section

Dict. 25

B*MEV Barns * MeV B*E 1.E+6 Z

We also propose that the derived s-factors should be allowed in the same subentry as the quantity from which they are derived.

Example:

```
REACTION  1(-----(-,-)----,,SIG)
          2(-----(-,-)-----,,SIG,,SFN)
```

Distribution:
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Thermonuclear Reaction Rate

Reaction Rate

Definition: The thermonuclear reaction rate is defined as the product of the energy-dependent cross section and the velocity averaged over the Maxwellian-Bolzmann distribution of relative velocities as a function of temperature:

$$\langle \sigma \cdot v \rangle = \frac{(8/\pi)^{1/2}}{m^{1/2}(kT)^{3/2}} \int \sigma(E) E \exp(-E/kT)\, dE$$

The particle with the mass m_2 has the velocity v relative to the target of mass m_1. The reduced mass m of the pair is $m = m_1 m_2/(m_1 + m_2)$.

REACTION Coding: (.....,SGV,,MXW)

Data Units: data are usually given in units of cm^3/sec and coded with the data unit CM3/SEC.

Energy Coding: Data are given as function of the Maxwellian temperature (kT) which is coded under the data heading KT with units of energy. See **Spectrum Average** for definition of incident spectrum.

s-factor

The reactivity of a plasma in thermal equilibrium at temperature T can be written in a form in which its main temperature dependence, which arises from the energy dependences in the cross section produced by the de Broglie wavelength and the Coulomb penetrability, is factored out, leaving a Maxwellian-Boltzmann averaged S function <S>.

$$\langle \sigma \cdot v \rangle = (2/m)^{1/2} \frac{\Delta E_0}{(kT)^{3/2}} \langle S \rangle \exp(-\tau)$$

REACTION Coding: (.....,SGV,,SFN)

See also **Cross Sections, Astrophysical s-factor**.

References:

1. D. D. Clayton, ***Principles of Stellar Evolution and Nucleosynthesis*** (McGraw-Hill, New York, 1968)
2. W. A. Fowler, et al, *Thermonuclear Reaction Rates*, ***Ann. Rev. Astron. Ap.*** **5**, 525 (1967)
3. C. A. Barnes, ***Advances in Nuclear Physics***, vol. 4, p. 133 (Plenum, New York, 1971).
4. Z. Y. Bao and F. Käppeler, ***Atomic Data & Nuclear Data Tables*** **36**, 412 (1987)

To be added to **Cross Sections**

Astrophysical s-factor

For nonresonant reactions between low-energy charged particles, the steepest dependence of σ(E) is contained in the penetration factor for the Coulomb and angular momentum barrier. For incident energies small compared to the height of these barriers, it is convenient to factor out the energy dependence, and an additional factor of 1/E. The cross section can then be written:

in terms of the Coulomb parameter

$$\sigma(E) = \frac{S(E)}{E}\exp(-2\pi\eta)$$

$$\eta = Z_1 Z_2 e^2/h\nu$$

where ν = relative velocity
Z_1, Z_2 = charge of incident ion and target, respectively

or in terms of the Gamow energy

$$\sigma(E) = S(E)\exp[-\beta/\sqrt{E}]/E$$

$$\beta = 0.98948 Z_1 Z_2 m^{1/2} \quad [units MeV^{1/2}]$$

where E = center-of-mass incident energy (MeV)
Z_1, Z_2 = charge of incident ion and target, respectively
m = reduced mass of system: $m = m_1 m_2/(m_1 + m_2)$

REACTION Coding: (.....,SIG,,SFN)

Data Units: data are usually given in units of eV b and coded with the data unit B*EV.

See also **Thermonuclear Reaction Rates**.