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Memo CP-D/622

Date: 11 March 2010
To: Distribution
From: N. Otsuka, V. McLane, O. Schwerer, S. Dunaeva
Subject: **Reaction Coding (SF1-SF2)**
Reference: Memo CP-D/607

Below is update of the EXFOR Formats Manual and LEXFOR entries "Center-of-Mass System" and "Incident-Projectile Energy" We plan to follow up shortly with a memo on Reaction Coding (SF3-SF4).

1) Proposed revision of the EXFOR Formats Manual 6:

Reaction field

…

Notes on SF1 and SF2

Target is given in SF1 and the incident projectile is given in SF2. If the incident energy is given in center-of-mass energy (EN-CM) or laboratory incident energy per nucleon (MEV/A, *etc.*), and reversing the order of the target and the projectile does not change the numerical data, the REACTION is coded using the tautology formalism. See LEXFOR **Incident Particles** for use of the tautology formalism for inverse kinematics. When such a tautology is given, an explanation about the sample and incident particle beam must be given under `SAMPLE` and `INC-SOURCE`.

Example:

```
REACTION    ((1-H-2(9-F-19,P)9-F-20,,SIG)=
            (9-F-19(1-H-2,P)9-F-20,,SIG))
```

(Cross section for ^{2}H(^{19}F,p)^{20}F given with incident energy in center-of-mass)

2) Proposed revision of LEXFOR "Center-of-Mass System":

Center-of-Mass System

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Note: Only one representation (*i.e.*, either laboratory or center-of-mass) for each parameter may be coded as a variable in the data table. The other representation may be added under the data heading `MISC` if considered desirable by the compiler. In case of doubt, the laboratory system is preferred.

Centre-of-Mass Energy and Incident Energy per Nucleon

Note that the centre-of-mass energy (EN-CM) is defined as

$$E_{cm} = E_{\text{proj,lab}} M_{\text{targ}} / \left(M_{\text{proj}} + M_{\text{targ}}\right) = E_{\text{proj,cm}} + E_{\text{targ,cm}} = Mc^2 - \left(M_{\text{proj}} + M_{\text{targ}}\right) c^2$$

(M: invariant mass in relativistic kinematics). It is clear from the 3rd and 4th term that the centre-of-mass is invariant under exchange of the incident projectile and the target. Because the numerator of the 2nd term can be rewritten as ($E_{\text{proj,lab}}$/ M_{proj}) M_{proj} M_{targ} , the incident energy in laboratory system per projectile mass (number) (MeV/A, *etc.*) is also invariant under this exchange. This invariance is not valid when the Debye effect (shielding of the nuclear Coulomb field by bound atomic electrons) enhances the cross section. This is observed in several reactions such as ^{3}He(d,p)^{4}He, ^{6}Li(p,α)^{3}He, ^{6}Li(d,α)^{4}He and ^{6}Li(p,α)^{4}He at low energy.

3) Proposed revision of LEXFOR "Incident-Projectile Energy (to be renamed)":

Incident Particles

In general, the incident projectile is coded in `REACTION` SF2 and the target is given in SF1. (Particles resulting from the `REACTION` to be defined are given in SF3 and SF4, see Outgoing **Particles**[1]).

Incident-Projectile Energy

(See also **Spectrum Average**.)

The energy of the incident projectile is entered in the COMMON or DATA section under the appropriate data heading (*i.e.*, a data heading from Dictionary 24 having an A in column 66).

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Information on the **characteristics of the resolution and the spectrum** of the incident-projectile beam is entered in free text under the keyword `INC-SPECT`. (See EXFOR Exchange Formats Manual Chapter 7: INC-SPECT).

Inverse kinematics

If the incident energy is given in center-of-mass energy (EN-CM) or laboratory incident energy per nucleon (MEV/A etc.), $A_{\text{targ}} \leq 4$ and $A_{\text{proj}} \geq 5$ in the experiment, and reversing the order of the target and the projectile does not change the numerical data, REACTION must be coded using the tautology formalism. This helps users when inverse kinematics technique is applied. The target and projectile used in the experiment should be in the left hand side of REACTION.

Examples:

```
REACTION     ((1-H-2(9-F-19,P)9-F-20,,SIG)=
             (9-F-19(1-H-2,P)9-F-20,,SIG))
```

(Cross section for ^{2}H(^{19}F,p)^{20}F given with center-of-mass energy)

[1] [1] LEXFOR entry to follow in memo on REACTION SF3-SF4.

```
REACTION    ((1-H-1(9-F-19,EL)1-H-1,,DA,P)=
            (9-F-19(P,EL)9-F-19,,DA,RSD))
```
(Proton angular distribution for $^{1}H(^{19}F,p)^{19}F$ given with center-of-mass energy and centre-of-mass angle.)

See also, **Center-of-Mass System.**

Nuclear Quantities

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