

Brookhaven Nat Lab

⇒ CP-Memo

MEMO CP-C/40

DA-1324-0

Date: May 10, 1973
From: T. Burrows, V. McLane
Subject: I. Spallation and Fission
II. Variable Product Nucleus

I. Spallation and Fission

We agree with the NDS discussion of memo CP-D/60. However, in the articles we have encountered, what is measured is a process, e.g. (p, n α), or a reaction product; the reaction is attributed to spallation due to theoretical considerations only. For this reason, we propose the addition of 'SPL' to SF5.

It is also true that this is usually the case for high energy fission. Therefore, using the same arguments found in CP-D/60, a code for high-energy fission should be introduced for SF5.

See LEXFOR entries attached.

II. Variable Product Nucleus (VPN)

We agree with NDS that we are very close to agreement on VPN. We disagree, however, on the need for the addition of the code 'DEF' in SF5 (CP-B/23). In the case where the particles specified in SF3 have not been directly measured, the particles measured should be specified under PART-DET.

The VPN formalism would be acceptable for all cases where SF3 contains the codes F, X or SPL.

Example:

Z-S-A (P,A+X) ELEM/MASS

See LEXFOR entry attached.

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Sol Pearlstein

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Product Yields

[Use in REACTION formalism]

Definition

Product yield data shall be defined as all data for which the reaction as specified may lead to more than one reaction product and for which the reaction product is one of the parameters of the data presented.

Note: Currently the processes for which this applies are fission, spallation and production data (F, SPL or X in SF3).

See also: Fission Yields, Reaction Mechanisms

Specification of the product nucleus

- a.) In the case where there is one specific reaction product given for the data table, the product may be coded as specified for reaction SF4. (See Reaction Products).
- b.) In the case where the data are given for more than one nucleus, the nuclei will be specified in the COMMON and DATA sections using the Data-Heading Keywords ELEMENT and MASS.

In this case SF4 contains the code:

ELEM - if the column-heading ELEMENT is used in the DATA table

MASS - if the column-heading MASS is used in the DATA table

ELEM/MASS - if the column-headings ELEMENT and MASS are used in either the COMMON section or the DATA table.

SF4 is the only subfield that may become a variable by using this formalism. All other subfields of the REACTION code must apply unchanged for the given subentry.

Examples for coding product-nuclei as variables in the DATA tables:

(8-0-16(P,X)ELEM/MASS,,SIG) = cross section of specified product nuclei which are given in the DATA table under the column headings ELEMENT and MASS and (if applicable) ISOMER. If the DATA table contains only isotopes of a single element, the column ELEMENT may be given in the COMMON section. Similarly, if a "charge dispersion" is given, MASS may appear in the COMMON section with ELEMENT as a variable in the DATA table.

(92-U-235(N,F)MASS,CHN,YLD) = "chain yield" of several mass-numbers given in the DATA table under the column heading MASS (compare under Fission Yields). The DATA table may consist of only a single line, when the "chain yield" for only one mass-number is given.

Reaction MechanismsDefinitions

The following reaction mechanisms are defined, based on currently accepted nuclear models.

Compound-Nucleus Interaction: A reaction in which the incident projectile is absorbed by the target nucleus and its initial energy is assumed to be shared by all other nucleons, such that the mode of disintegration of the 'compound nucleus' is independent of the way in which it was produced.

Direct Interaction: A reaction in which there is direct interaction between the incident projectile and single nucleons or clusters of nucleons in the target.

Spallation: A reaction where several particles are ejected from the target nucleus by direct interaction leaving behind a nucleus in an excited state, which then evaporates nucleons or clusters of nucleons.

High-energy Fission (Energies > about 50 MeV): proceeds in essentially the same manner as spallation except that the excited nucleus divides into roughly two fragments.

See Fission for the fission process at lower energies.

Data Specification1. Compound-Nucleus Interaction and Direct Interaction

Some reactions may proceed by either mode in which case, the total reaction is equal to the sum of the compound-nucleus interaction and direct interaction portions. In this case, the partial cross-sections for the compound-nucleus interaction and direct interaction portions of a reaction may be coded with the modifiers 'CN' and 'DI', respectively, in quantity SF3 (modifier) for the keyword ISO-QUANT, or, in SF5 (branch) for the keyword REACTION.

Examples:	<u>ISO-QUANT</u>	<u>REACTION</u>
	(----,NP,,CN)	(----(N,P),CN,SIG)
	(----,NP,,DI)	(----(N,P),DI,SIG)

These partial cross-sections cannot be measured directly but are deduced from theoretical considerations. Therefore, careful explanation in free text is required whenever these modifiers are used.

Note: If the author measures the total (n,p) cross-section and states that this reaction is totally a direct interaction, then the modifier "DI" must not be given, because "DI" and "CN" designate partial cross-sections.

2. Spallation and High-energy Fission

In the case where the reaction mechanism can be determined experimentally, fission or spallation data may be coded using the process codes 'F' or 'SPL', respectively, in SF3 of the REACTION keyword.

Examples:

(6-C-12 (P,F),,SIG)

(6-C-12 (P,SPL),,SIG)

The breakup of a nucleus at high energies may, in some cases, proceed by either mode. In this case, the partial quantity for fission or spallation may be coded under the keyword REACTION using the modifiers 'SPL' and 'FIS', respectively, in SF5 (branch). SF3 (Process) will contain the code 'X'.

Examples:

(6-C-12(P,X),SPL,SIG) Spallation part of breakup
cross section

(6-C-12(P,X),FIS,SIG) High-energy part of breakup
fission cross section

Note: The total breakup will be coded without these modifiers.

For the production of specified product nuclei see Product Yields.

Reaction Product

[Use in REACTION formalism]

Definition:

In general, the heaviest of all identifiable products of the reaction is defined as the Reaction Product (also called Residual Nucleus) to be coded into SF4 of the REACTION keyword.

Exceptions or special cases are:

- a.) If the sequence of outgoing particles is meaningful (i.e., SF5 contains the code SEQ), the heaviest of the final products should be coded in SF4. This may not be the heaviest of all products.

Example: 5-B-10(N,A+T)2-HE-4,SEQ,SIG

- b.) If the reaction product is not defined as in the case of the total cross section (TOT in SF3), absorption and nonelastic processes (ABS and NON in SF3), and, in some cases, for the fission process (F in SF3), e.g., total fission cross section, SF4 is left blank.

- c.) When quantities are given for the yield of specified nuclides, particles or radiations.

(F, SPL or X in SF3), the product considered is coded in SF4 (regardless of whether it is the heaviest reaction product).

See Product Yields.

Coding

- a.) The Reaction Product as defined above is coded in SF4 in the form Z-S-A-X as defined on page VIII.3. If light particles or gammas are defined as Reaction Product, these are coded in SF4 in the Z-S-A form identical to the coding in the target-field SF1. In addition, the code

0-G-0 for gammas

is used in analogy to the codes

1-H-1 for protons, or

0-NN-1 for neutrons,

Thus, the particle codes (A,HE3,T,D,P,N,G) are not used in SF4.

Examples:

(92-U-235(N,F)04-XE-124,CHN,YLD) = cum.yield of Xe-124
(92-U-235(N,F)2-HE-4,TER,DA,A) = ang.distr. of ternary fission
alphas
but: (92-U-235(N,F),,DA,FF) = ang.distr. of unspecified fission
fragments
(28-NI-0(N,X)0-G-0,,SIC) = gamma production cross section

b.) Variable Product Nucleus

In the case where a process results in the production of more than one nucleus, and the data are given a function of these product nuclei, the reaction products may be entered into the data table as variables under the Data-Heading Keywords ELEMENT and/or MASS.

In this case SF4 contains the code:

ELEM - if the column-heading ELEMENT is used in the DATA table
MASS - if the column-heading MASS is used in the DATA table
ELEM/MASS - if the column-headings ELEMENT and MASS are used in
either the COMMON section or the DATA table.

Note: At present this is limited for use with the process codes F, SPI, and X in SF3.

Examples:

(26-FE-56(P,A+X)ELEM/MASS,,SIG)
(92-U-235(N,F)MASS,CHN,YLD)