To: Distribution

From: M. Lammer

Subject: CINDA manual revision: coding of (2n,f), (n,n'f) and (n,2nf) reactions

CINDA Action no. 59 from the 1992 NRDC meeting was to draft coding hints for reactions (2n,f) and (n,n'f) as proposed manual revision for pages II.2.8 (hints for coding such cases) and II.2.17 (note under the heading "fission quantities"). Action 44 from the 1994 NRDC meeting was to reviewthe original memo; the revised wording is given below:

Addition to Page II.2.8:

(2n,f) reaction

In this process, 2 neutrons are captured almost simultaneously before the compund nucleus (Z,A+2) undergoes fission.

Cross sections for this process as well as "eta" and "alpha" should be entered for the target nucleus and the quantity NF with an appropriate comment, e.g.: "(2N,F)" or "(2N,F) REAC".

Other fission quantities (NU,NFY,FRS,etc.) are determined by the compound nucleus which is the same as after (n,f) reaction for the target nucleus (Z,A+1).   Therefore entries should be made for the "target nucleus" (Z,A+1) with the corresponding quantity. The comment should contain the real target nucleus and "(2N,F)" or "(2N,F) REAC" or "YLD FROM U235(2N,F)" etc.

(n,n'f) and (n,2nf) reactions: instant fission

In the (n,n'f) resp. (n,2nf) reaction, 1 resp. 2 neutrons are emitted, leading to an excited level with negligible lifetime which undergoes instant fission (second resp. third chance fission). These processes can experimentally not be separated from the (n,f) reaction and are considered as part of it. Therefore entries for all quantities should be made as for (n,f) reactions.

(n,n'f) reaction: delayed fission

In this case, the (n,n') reaction leads to the formation of a spontaneously fissioning (shape) isomer of non-negligible lifetime with the same (Z,A) as the target nucleus. Therefore the target nucleus is always entered.

Cross sections for the whole process: entries should be made for the quantities NF and DIN (since it is a partial inelastic scattering cross section) with the incident neutron energy and appropriate comments, e.g.: "(N,N'F)" or "(N,N'F) REAC" or "SIG FOR (N,N'F)".

Other fission quantities: entries should be made for the quantity measured using "SPON" for the energy. An appropriate comment is required, e.g.: "SPONT FISS ISOMER" or "FROM ISOMER AFTER (N,N')" or "FROM U235(N,N')U235M(SF)". If no information on the (n,n') reaction is given, no corresponding entry for DIN should be made.

Note: If the inelastic scattering cross section for the formation of the spontaneously fissioning isomer is given together with other fission quantities, entries should be made for the the target nucleus and the (n,n') reaction as well as for the reported quantities for the spontaneously fissioning isomer as above, with appropriate comments.

(n,2nf) reaction: delayed fission

This case is similar to the (n,n'f) reaction except that 2 neutrons are emitted before formation of the spontaneously fissioning isomer (Z,A-1). The considerations of the processes and coding rules for CINDA follow those of the (n,n'f) reaction except that for the cross section for the whole process, N2N replaces DIN, and for the other fission quantities the target nucleus is the spontaneously fissiong isomer (Z,A-1).

Revision of Page II.2.11:

under DIN   Diff Inelast: Definition: Angular distributions or
                                      energy spectra of inelastically scat-
                                      tered neutrons, or partial cross-
                                      sections.

                                   Examples of use:
                                   ....
                                   4) cross-section for (n,n'f) reaction
                                      (see also pages II.2.8 and II.2.17)

Revision of Page II.2.13:

under N2N   (N,2N)   Definition: ... no change

                                   Use: For cross sections .... emitted.
                                   Include: cross-section for (n,2nf) reaction (see
                                   also pages II.2.8 and II.2.17)
                                   Exclude: (n,f) and (n,3n) reaction.

Revision of Page II.2.17 (at top of page before NF):

Fission quantities

Summary table of coding rules for (2n,f), (n,n'f) and (n,2nf) reactions (for details and coding hints see page II.2.8):

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                              |         |    delayed    |
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quantities/ what to be coded              | (2n,f)  | (n,n'f)  | (n,2nf)  |
=================================================|=========|=========|=========|
                    | target nucleus +)   | (Z,A)   | (Z,A)   | (Z,A)   |
 whole process:     |---------------------|---------|---------|---------|
                    | neutron energy      | incident | incident | incident |
 NF RIF ALF ETA     |---------------------|---------|---------|---------|
                    | additional quantity *) |  -    | DIN    | N2N    |
=================================================|=========|=========|=========|
 other quantities:  | target nucleus +)   | (Z,A+1) | (Z,A)   | (Z,A-1) |
 NU NUD NUF SFN SFG |---------------------|---------|---------|---------|
 FPG FPB NFY FRS CHG | neutron energy     | incident | SPON   | SPON   |
=================================================================================
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+) target nucleus for CINDA, where (Z,A) is the published target nucleus
*) only if information on the cross section is given