WP 2004-12
(CP-D/333, D/378, C/331)

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Memo CP-C/333

DATE: January 16, 2004
TO: Distribution
FROM: V. McLane
SUBJECT: Quasi-metastable states (CP-C/331, CP-D/378)

I agree with Otto's comments with the following clarification. The quasi-isomeric state data are the result of activation measurements, so what is measured is the half-life and decay radiations. If the level energy is given, it is only additional information (similar ti other metastable states). Therefore, the heading LVL, and others of that type may be used, but not `E-LVL`. Conversely, if the data are not the result of an activation measurement, this formalism should not be used. Half-life, in this case, is additional information and may be given in free text as before.

There has been no agreement to allow `LVL`, `LVL-INI`, and `LVL-FIN` to be entered under `LEVEL-PROP`. The rules for which headings can be used are strictly put down in the Manual. Do we really need these under `LEVEL-PROP` since they are, in any case, only additional information, and most likely taken from another reference? In my opinion, when the level properties are taken from, *e.g.*, Table of Isotopes, and are simply additional information, that is, not needed to identify the level, this keyword should not be used. (We are not in the nuclear structure compilation business).

An EXFOR Manual update, and a LEXFOR update for Isomeric State follows. I will update partial reactions accordingly.

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Updates to LEXFOR entry on Isomeric States

Definition: An isomeric state is defined as a long-lived energy state, where long-lived is, generally, accepted as having a half-life greater than ~0.1 second.

A ***metastable state*** is an excited state having a half-life of the order of 0.1 seconds or longer. The term 'isomeric states' refers to the ground and all known metastable states.

Add at end of entry

Quasi-metastable states (metastable states with a measurable half-life less than 0.1 seconds.

When activation data are measured for quasi-metastable states, that is, the half-life and decay radiations are measured for the level, the excited state is specified using an isomer extension of the type `L`, `L1`, *etc*., in the isomer code in `REACTION` subfield 4. The significance of the extension is simply to link the levels with the decay data, and would be significant only within a given data set.

Examples:

```
BIB
REACTION  1 (39-Y-89(N,2N)39-Y-88-L1,,SIG)
          2 (39-Y-89(N,2N)39-Y-88-L2,,SIG)
          G (39-Y-89(N,2N)39-Y-88-G,,SIG)
SAMPLE      99.99% enriched Y2O3 sample.
DECAY-DATA1 (39-Y-88-L1,320.MICROSEC,DG,392.7)
          2 (39-Y-88-L2,14.6MSEC,DG,232.2,,DG,442.8)
          G (39-Y-88-G,107.D,DG,898.,,DG,1836.)
ENDBIB
```

```
BIB
REACTION    (81-TL-203(N,2N)81-TL-202-L/G,,SIG/RAT)
SAMPLE      99.99% enriched TlCl sample.
DECAY-DATA  (81-TL-202-L,536.MICROSEC,DG,459.6,,DG,490.7)
            (81-TL-202-G,12.5D,DG,439.7,,DG,969.6)
ENDBIB
```

Update to EXFOR Manual Chapter 6.

Coding of nuclides and compounds

Nuclides appear in the coding of many keywords. The general code format is *Z-S-A-X*, where:

- *Z* is the charge number; up to 3 digits, no leading zeros
- *S* is the element symbol; 1 or 2 characters (Dictionary 8)
- *A* is the mass number; up to 3 digits, no leading zeroes. A single zero denotes natural isotopic composition (limited to special cases as given under the specific keyword).
- X is an isomer code denoting the isomeric state (this subfield may be omitted)
  X may have the following values:
  - `G` for ground state (of a nucleus which has a metastable state)
  - `M` if only one metastable state is regarded
  - `M1` for the first metastable state
  - `M2` for the second, *etc.*
  - `T` for sum of all isomers (limited to use within an isomeric ratio in SF4 of the reaction string)
  - `L` if only one quasi-metastable state is regarded
  - `L1` for the first quasi-metastable state, *etc*.

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Memo CP-D/378

Date: 16 January 2004
To: Distribution
From: O. Schwerer

Subject: Quasi-metastable states (Reply to memo CP-C/331)

I agree to the proposal of CP-C/331 provided that a few more clarifications are introduced as follows.

1. The LEXFOR page on **Isomeric States** presently gives 3 different criteria for what is a "short" half-life:

"**Isomeric** states" must have a half-life **> 0.1 seconds,** except for spontaneous fission, α or p decay, where it is **> 1 milli-second**. The next paragraph says that "for practical applications, a ***metastable*** state in EXFOR is defined as having a half-life of **0.1 milliseconds** or longer".

With the new formalism, we can do away with this confusing situation. I propose to define that metastable states with half-lives of **0.1 seconds** or longer are coded with **-M, M1** etc while all states with shorter half-lives are coded with -L, L1 etc.

2. With these new codes we come close to the area of "ordinary partial cross sections" which are coded not with isomeric extension in SF4 but with PAR in SF5. Therefore, the LEXFOR page on **Partial Reactions** should say

"Partial cross sections leading to an **isomeric state** (with a half-life >0.1 sec) are coded with an isomer extension in REACTION SF4. Partial cross sections for **quasi-metastable** states, which are characterized by a half-life below 0.1 sec, are coded with isomer extension -L, L1, L2 etc. which link the levels with DECAY-DATA and are valid only for this particular data set.
Partial cross sections leading to individual levels for which **no half-life** is given but which are characterized by the level energy or level number, are coded without an isomer extension in SF4 but with PAR in SF5, and the level identification is given under the data headings E-LVL or LVL-NUMB (or equivalent)."

3. What if **both** the half-life and the level energy of a quasi-metastable state are given?
I think we should have the possibility to give them both, either by

- Allowing to give the level energy under LEVEL-PROP, **even if neither spin nor parity are given (this would be new)**; or

- Giving the level energies under new data headings such as LVL-L1, LVL-L2. (It would be LVL-L1 rather than E-LVL-L1 because it's not a required independent variable but rather "additional information" much like LVL-INI and LVL-FIN.)

I prefer the first possibility:

LEVEL-PROP (39-Y-88-L1,E-LVL=0.674)

because if necessary spin and parity can be added without having too much redundance.

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Memo CP-C/331

DATE: January 14, 2004
TO: Distribution
FROM: V. McLane
SUBJECT: Quasi-metastable states

Quasi-metastable states, that is, states with a measurable half-life less than 0.1 seconds, is a problem that I know has been discussed before. Solutions have been proposed, but I don't remember any resolution. (I looked back through the 1996 NRDC Meeting minutes, but didn't see anything).

In correcting some older data, I have come across a case of data measured by activation for some quasi-metastable states. At the time, they were compiled, they were given metastable state numbers. This is not a perfect solution, as there may be metastable states interspersed with these short-lived levels.

I propose that we allow a new set of isomer extensions, L, L1, L2, *etc*. The significance of the extension is simply to link the levels with the decay data, and would be significant only within a given data set. (I think this is similar to what had already been proposed).

An example is given following.

```
ENTRY            10493
SUBENT        10493001
BIB
INSTITUTE  (1USASMU)
REFERENCE  (J,JIN,37,1121,197505)
           (C,75WASH,2,712,197503)
AUTHOR     (P.K.Eapen,G.N.Salaita)
TITLE      Isomeric cross-section ratios for (n,2n) reactions at
            14.8 MeV
HISTORY    (19750417C)
ENDBIB
COMMON
EN
MEV
 14.8
ENDCOMMON
ENDSUBENT
SUBENT        10493008
BIB
REACTION  1(39-Y-89(N,2N)39-Y-88-L1,,SIG)
          2(39-Y-89(N,2N)39-Y-88-L2,,SIG)
          G(39-Y-89(N,2N)39-Y-88-G,,SIG)
SAMPLE     99.99% enriched Y2O3 sample.
DECAY-DATA1(39-Y-88-L1,320.MICROSEC,DG,392.7)
          2(39-Y-88-L2,14.6MSEC,DG,232.2,,DG,442.8)
          G(39-Y-88-G,107.D,DG,898.,,DG,1836.)
ENDBIB
NOCOMMON
DATA
DATA      1DATA-ERR  1DATA      2DATA-ERR  2DATA      GDATA-ERR  G
MB         MB         MB         MB         MB         MB
 96.        8.        227.       18.        1292.      103.
ENDDATA
ENDSUBENT
SUBENT        10493011
BIB
REACTION   (39-Y-89(N,2N)39-Y-88-L1+L2/G,,SIG/RAT)
SAMPLE     99.99% enriched Y2O3 sample.
DECAY-DATA (39-Y-88-L1,320.MICROSEC,DG,392.7)
           (39-Y-88-L2,14.6MSEC,DG,232.2,,DG,442.8)
           (39-Y-88-G,107.D,DG,898.,,DG,1836.)
STATUS     (DEP,10493008)
ENDBIB
NOCOMMON
DATA
DATA       DATA-ERR
NO-DIM     NO-DIM
0.250      0.030
ENDDATA
ENDSUBENT
```

```
SUBENT        10493018
BIB
REACTION  L(81-TL-203(N,2N)81-TL-202-L,,SIG)
          G(81-TL-203(N,2N)81-TL-202-G,,SIG)
SAMPLE     99.99% enriched TlCl sample.
DECAY-DATAL(81-TL-202-L,536.MICROSEC,DG,459.6,,DG,490.7)
          G(81-TL-202-G,12.5D,DG,439.7,,DG,969.6)
ENDBIB
NOCOMMON
DATA
DATA      LDATA-ERR  LDATA      GDATA-ERR  G
MB         MB         MB         MB
670.       54.        2482.      198.
ENDDATA
ENDSUBENT
SUBENT        10493020
BIB
REACTION   (81-TL-203(N,2N)81-TL-202-L/G,,SIG/RAT)
SAMPLE     99.99% enriched TlCl sample.
DECAY-DATA (81-TL-202-L,536.MICROSEC,DG,459.6,,DG,490.7)
           (81-TL-202-G,12.5D,DG,439.7,,DG,969.6)
STATUS     (DEP,10493018)
ENDBIB
NOCOMMON
DATA
DATA       DATA-ERR
NO-DIM     NO-DIM
0.270      0.036
ENDDATA
ENDSUBENT
ENDENTRY
```