WP 2005-29

Included: CP-E/071 and CP-D/434

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Memo CP-E/071 (Revised)

Date: September 21, 2005
To: Distribution
From: OTSUKA Naohiko
Subject: Energy spectrum as function of sum of kinetic energies of several particles
Reference: CP-D/434

We have two comments on Memo CP-D/434:

1) This is an extension of "Energy distribution for a correlated pair" (LEXFOR Secondary Energy Distributions item.2) to *N*-particle case, because relative energy E_{rel} is the total kinetic energies of two particles in their center of mass system (c. m. s.), and M. Meister *et al*. considers the total kinetic energies of 3 particles in their c. m. s. (=outgoing ^{6}He or ^{8}He rest frame).

   Therefore it would be better to keep consistency between two particles case and *N*-particles case, for example,

   - Codes for particles considered (SF7): `a+b+…` or `a/b/…` ?
   - Heading for the total kinetic energies in their c. m. s.: `E`, `E-CM` or `E-RL-CM` ?

   I think the reference frame of kinetic energies (laboratory system, c. m. s. of projectile-target, c. m. s. of particles considered…) should be clarified by heading and/or `EN-SEC`.

2) JCPRG has compiled similar quantity (Energy spectrum of Coulomb excited outgoing particle) in E1915.002, in which energy spectrum of Pb(^{11}Be, n+^{10}Be)Pb is given for the relative energy for n-^{10}Be(=total kinetic energies in their c. m. s.). We treated this data as energy spectrum of outgoing ^{11}Be excitation energy, because total kinetic energy in n-^{10}Be c. m. s. is equal to excitation energy of ^{11}Be (measured from n-^{10}Be threshold). This could be another solution for M. Meister *et al*.

3) Addition of new item for total kinetic energy to LEXFOR is useful. This quantity is often needed in the compilation of fission measurement, in which some works consider total kinetic energy of fission fragments (e.g. light fragment and heavy fragment).

Sample of coded entry (E1915.002)

N. Fukuda *et al*., Phys. Rev., C **70** (2004) 054606 Fig.2 (a).

```
SUBENT        E1915001   20050916                                  E191500100001
BIB                 12         37                                  E191500100002
…
PART-DET    (N)                                                    E191500100015
            (4-BE-10)                                              E191500100016
…
METHOD      (COINC) Detect neutron and 10Be in coincidence.        E191500100020
            (EDE)                                                  E191500100021
            (TOF) To deduce momentum vector of 10Be and neutron    E191500100022
…
COMMENT     In some data tables, excitation energy of 11Be is      E191500100035
            measured from 10Be-n threshold. Authors mention that   E191500100036
            the one-neutron separation energy is precisely known   E191500100037
            to be 504+-4 keV.                                      E191500100038
HISTORY     (20050421C) Sr + On                                    E191500100039
ENDBIB              37          0                                  E191500100040
NOCOMMON             0          0                                  E191500100041
ENDSUBENT           40          0                                  E191500199999
SUBENT        E1915002   20050916                                  E191500200001
BIB                  7         21                                  E191500200002
REACTION    (82-PB-0(4-BE-11,INL)82-PB-0,,IPA/DE)                  E191500200003
EN-SEC      ANG-CM is polar angle between beam and 11Be in center  E191500200004
            of mass system                                         E191500200005
            (E-EXC,4-BE-11) Relative energy between 10Be and       E191500200006
                            neutron (= Excitation energy of 11Be   E191500200007
                            measured from 10Be-n threshold)        E191500200008
…
ENDBIB              21          0                                  E191500200024
COMMON               3          3                                  E191500200025
EN          ANG-CM-MIN ANG-CM-MAX                                  E191500200026
MEV/A       ADEG       ADEG                                        E191500200027
 68.7        0.0         6.0                                       E191500200028
ENDCOMMON            3          0                                  E191500200029
DATA                 3         60                                  E191500200030
E-EXC       DATA       DATA-ERR                                    E191500200031
MEV         B/MEV      B/MEV                                       E191500200032
  5.576E-02  6.695E-01  3.474E-02                                  E191500200033
  1.504E-01  1.337E+00  2.963E-02                                  E191500200034
…
  3.678E+01  7.046E+00  2.429E+00                                  E191500200091
  4.177E+01  1.478E+01  4.053E+00                                  E191500200092
ENDDATA             62          0                                  E191500200093
ENDSUBENT           92          0                                  E191500299999
```

Nuclear Data Section
International Atomic Energy Agency
P.O.Box 100, A-1400 Vienna, Austria

Memo CP-D/434

Date: 10 May 2005
To: Distribution
From: S.Dunaeva, O.Schwerer

Subject: Energy spectrum as function of sum of kinetic energies of several particles (Addition to Dictionary 36 and to LEXFOR)

The following code is proposed for inclusion in dictionary 36:

Quantity	Independent Variable	Unit dimension	Reference
,DE,N/N/A	E	DE	NP/A,700,3,2002

,DE,N/N/A – Energy spectrum as a function of the sum of kinetic energies of alpha particle and two neutrons.

The secondary energy is to be defined under EN-SEC:

EN-SEC (E,N/N/A) – sum of kinetic energies of alpha particle and two neutrons

Many experiments were done in this specific manner:

(J,NP/A,700,3,2002) (see example entry, Appendix 2)
(J,NP/A,633,234,1998)
(J,NP/A,679,462,2001), etc.

(In all these publications the excitation-energy spectrum was reconstructed from the measured momenta of the two neutrons and the alpha particle after dissociation.)

Since this is a new type of energy distribution, an addition to the LEXFOR page on **Differential Data** is proposed as well (**Appendix 1**).

An example entry is given as **Appendix 2**.

Appendix 1

Proposed addition of new **item 5.** to page D.12 of LEXFOR page **Differential Data**

Secondary Energy Distributions

1. Energy distribution: probability for a particle to be emitted with a given energy E′ or in a given energy range E_{min} to E_{max}; given as $\sigma(E') = d\sigma/dE$. The data are given in units of cross section per unit of secondary energy (*e.g.*, mb/MeV).

REACTION coding: DE in SF6.
Unit type: DE (*e.g.*, B/MEV)

2. Energy distribution for a correlated pair: Probability that a particle *a* and a particle *b* will be emitted at a relative energy E_{rel}, usually given as the center-of-mass energy of the relative motion of the correlated pair:

REACTION coding: DE in SF6; particles in SF7 as *a*+*b* (*e.g.*, P+A).

Unit type: DE (*e.g.*, B/MEV)

The energy is given under the data heading E-RL-CM

3. Linear momentum distribution: probability for a particle to be emitted with a given momentum p′; given as $\sigma(p') = d\sigma/dp$. The data are given in units of cross section per unit of secondary linear momentum (*e.g.*, mb/MeV/c).

REACTION coding: DP in SF6.
Unit type: DA (*e.g.*, MB/MEV/C)

***Example*:**
(……(N,X)……,LP,DP) longitudinal momentum distribution of emitted particles.

The linear momentum is given under the data heading MOM-SEC.

4. Linear momentum distribution for a correlated pair: Probability that a particle *a* and a particle *b* will be emitted at a mean linear momentum p_m or a relative linear momentum p_{rel}.

REACTION coding: DP in SF6; particles in SF7 as *a*+*b* (*e.g.*, P+A).
Unit type: DP (*e.g.*, MB/MEV/C)

The linear momentum is given under the heading MOM-SEC-MN or MOM-SEC-RL.

5. Energy distribution as a function of the sum of kinetic energies of several particles: Probability that particles *a* and *b,* or particles *a*, *b,* and *c,* will be emitted with a total kinetic energy E.

REACTION coding: DE in SF6; particles in SF7 as *a*/*b*/*c* (*e.g.*, P/A/A).

Unit type: DE (*e.g.*, B/MEV)

Appendix 2

```
ENTRY            D0172   20050404                                D0172  0    1
SUBENT        D0172001   20050404                                D0172  1    1
BIB                9         32                                 D0172  1    2
TITLE      8He-6He: A comparative study of electromagnetic       D0172  1    3
           fragmentation reactions                               D0172  1    4
AUTHOR     (M.Meister, K.Markenroth, D.Aleksandrov, T.Aumann,    D0172  1    5
           T.Baumann, M.J.G.Borge, L.V.Chulkov, D.Cortina-Gil,   D0172  1    6
           B.Eberlein,Th.W.Elze,H.Emling,H.Geissel,M.Hellstrom,  D0172  1    7
           B.Jonson, J.V.Kratz, R.Kulessa, A.Leistenschneider,   D0172  1    8
           I.Mukha, G.Munzenberg, F.Nickel, T.Nilsson, G.Nyman,  D0172  1    9
           M.Pfutzner, V.Pribora, A.Richter, K.Riisager,         D0172  1   10
           C.Scheidenberger, G.Schrieder, H.Simon, O.Tengblad,   D0172  1   11
           M.V.Zhukov)                                           D0172  1   12
INSTITUTE  (2SWDCTH,2GERTHD,4RUSKUR,2GERGSI,2SPNSPN,2SPNSAU,     D0172  1   13
           2GERMNZ,2GERFRK,3POLUJK,2ZZZCER,2DENAAU)              D0172  1   14
REFERENCE  (J,NP/A,700,3,2002)                                   D0172  1   15
           (J,NP/A,633,234,1998) Tech. details.                  D0172  1   16
FACILITY   (SYNCH,2GERGSI) The heavy-ion synchrotron at GSI.     D0172  1   17
           The experiments were carried out at the               D0172  1   18
           ALADIN-LAND setup.                                    D0172  1   19
           (PRJFS,2GERGSI)The secondary beam of 227 MeV/u 8He    D0172  1   20
           and 240 MeV/u 6He was produced in a 8 g/cm2 beryllium D0172  1   21
           production target from a primary beam of 180 with     D0172  1   22
           an energy of 340 MeV/u. The 8He or 6He nuclei         D0172  1   23
           were separated out from the primary reaction          D0172  1   24
           products using the fragment separator FRS.            D0172  1   25
SAMPLE     Pb targets of thickness 0.387 g/cm2 and 0.87 g/cm2    D0172  1   26
           were used for 8He and 6He, respectively.              D0172  1   27
DETECTOR   (PSSCN) The selected events for the 8He breakup were  D0172  1   28
           coincidences between 6He and neutrons, detected in the D0172  1   29
           large area neutron detector, LAND, while alpha-neutron D0172  1   30
           coincidences were selected for 6He.                   D0172  1   31
STATUS     (TABLE) Tables received from Dr. L.V.Chulkov          D0172  1   32
           (APRVD) Entry was approved by Dr. M.Meister           D0172  1   33
HISTORY    (20050404C) SD                                        D0172  1   34
ENDBIB            32          0                                  D0172  1   35
NOCOMMON           0          0                                  D0172  1   36
ENDSUBENT         35          0                                  D0172  199999
SUBENT        D0172004   20040929                                D0172  4    1
BIB                4          7                                  D0172  4    2
REACTION   (82-PB-208(2-HE-6,2N+A)82-PB-208,,DE,N/N/A)           D0172  4    3
SAMPLE     Pb targets of thickness .87 g/cm2                     D0172  4    4
EN-SEC     (E,N/N/A)                                             D0172  4    5
COMMENT    The 6He excitation-energy (Ex) spectrum reconstructed D0172  4    6
           from measured momenta of the two neutrons and         D0172  4    7
           the alpha particle after dissociation                 D0172  4    8
           of 240 MeV/u 6He in a lead target.                    D0172  4    9
ENDBIB             7          0                                  D0172  4   10
COMMON             1          3                                  D0172  4   11
EN                                                               D0172  4   12
MEV/A                                                            D0172  4   13
  240.                                                           D0172  4   14
ENDCOMMON          3          0                                  D0172  4   15
DATA               3         61                                  D0172  4   16
E          DATA-CM    DATA-ERR                                   D0172  4   17
MEV        MB/MEV     MB/MEV                                     D0172  4   18
  1.125       1.2        1.2                                     D0172  4   19
  1.275      14.7        3.6                                     D0172  4   20
  1.425      25.4        5.8                                     D0172  4   21
 ……..
 ……..
  9.825      40.1       17.5                                     D0172  4   77
  9.975      45.2       14.9                                     D0172  4   78
 10.125      39.5       15.5                                     D0172  4   79
ENDDATA           63          0                                  D0172  4   80
ENDSUBENT         79          0                                  D0172  499999
```

ENDENTRY	11	0		D017299999999