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Memo CP-C/200

DATE: June 14, 1991
TO: Distribution
FROM: V.McLane, V.Varlamov
SUBJECT: Area M Photonuclear Data File Update

1. Multipolarity
2. Treiman-Yang Angle
3. Secondary Particle Correlations
4. Asymmetry
5. Mass ratios
6. High- and low-energy components of cross section
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12. Dictionary Update

This is a reworking of Memo CP-C/198, with some additions and changes, and taking into account the comments of Memo CP-D/215. We have included everything in this memo, for the convenience of having it all in one place.

We have also included some new proposals.

As we mentioned in the previous memo, we will be sending a complete update for all entries previously transmitted shortly. These files will supersede all previous transmissions.

cc. Arcilla, Ganesan, Lammer, Lemmel, Muir, Pashchenko, Schmidt, Schwerer, Wang Dahai

1. Multipolarity

Definition: Angular momentum of gamma-quanta absorbed by the nucleus. These are given as electrical or magnetic monopoles, dipoles, quadrupoles, or octupoles.

REACTION Coding: Specifier in SF5 for electric or magnetic polarity with polarity given in coded form under the data heading POLAR: 0 = monopole, 1 = dipole, 2 = quadrupole, 3 = octupole.

Example:

1) REACTION (.....(G,N).....,EP,SIG,,,EXP) electric dipole component of photoneutron cross section

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.
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COMMON
POLAR
NO-DIM
 1.
ENDCOMMON
```

2) REACTION (.....(G,ABS).....,MP,SIG,,,EXP) magnetic quadrupole component of photoabsorption cross section

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.
.
COMMON
POLAR
NO-DIM
 2.
ENDCOMMON
```
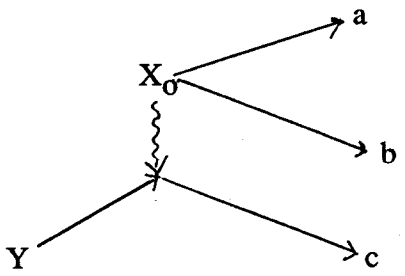
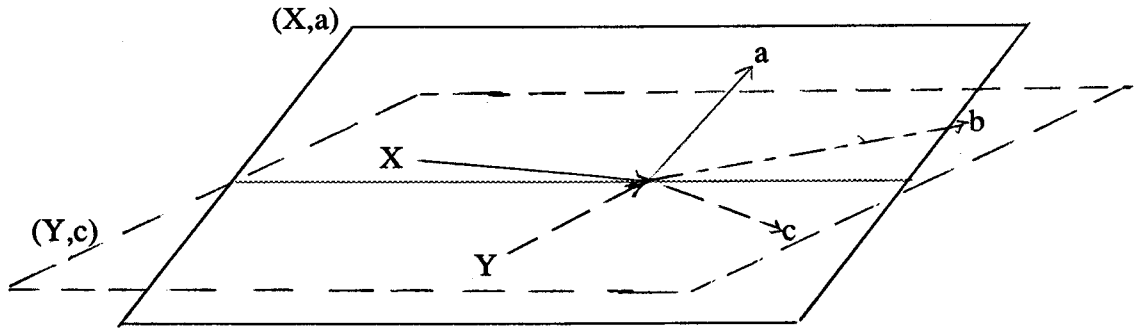

2. Treiman-Yang Angular Distribution

Definition: The angular distribution measured as a function of the angle between two reaction planes for three-particle final states in the anti-laboratory system (*i.e.*; X is at rest) That is, for the reaction between particles X and Y producing particles a, b, c (see diagram below), the angle between the planes (X,a,b) and (Y,c).



For photonuclear reactions in the center-of-mass system it is the angle between the (X,a) and (Y,b) or (Y,c) planes, where X is the incident gamma, Y is the target nucleus.



Reference: I.S.Shapiro, *et al.*, ***Nuclear Phys.*** 61, 353 (1965)

REACTION Coding: Parameter code TYA in SF6.

Example: REACTION (2-HE-4(G,N+P)1-H-2,,DA/TYA,P,,EXP) distribution over Treiman-Yang angle between (^{4}He,^{2}H) and (γ,p) planes in c.m. system

The reaction planes are defined as:

Plane 1: defined by target and residual nucleus

Plane 2: defined by incident projectile and particle designator

The data headings ANG-CM and DATA-CM should be used for the data.

3. Secondary Particle Correlations

We propose a modification to the coding for the Information-Identifier Keywords EN-SEC, MOM-SEC, AND EMS-SEC to allow for correlations between outgoing particles.

Particle Field. Contains one or more particles or nuclei to which the data-heading keyword refers.

either: a particle code from Dictionary 13

or: a nuclide coded in the standard format as described on page 8.3. Permitted nuclei are indicated in Dictionary 27 by a '3' in column 15.

For two particle codes, they are separated by a slash, and ordered "lightest" to "heaviest" as for REACTION subfield 3 (see page 8.R.4).

Examples: EN-SEC (E-LVL,3-LI-6)

EN-SEC (E1,N/P) relative energy of p-n pair

4. Asymmetry

The assymetry of the cross sections may be presented in a number of representations. We propose additions to Dictionary 36 (and Dictionary 34 (modifiers)) to handle the following cases.

a. Reaction coding: POL/DA,,ASY

Definition: The relative difference between particles scattered right and left in the same plane and at the same angle with the incident beam direction.

$$e = (L-R)/(L+R)$$

b. Reaction coding: POL/DA,,ASY/PP

Definition: The relative difference between the angular distribution for incident photons with their polarization vectors perpendicular and parallel to the reaction plane.

$$\Sigma = (d\sigma^{\perp} - d\sigma^{\parallel})/(d\sigma^{\parallel} + d\sigma^{\perp})$$

Data given as $\Sigma = (d\sigma^{\parallel} - d\sigma^{\perp})/(d\sigma^{\parallel} + d\sigma^{\perp})$ should be coded as the negative of the value given.

c. Reacion coding: POL/DA,,ASY/FB

Definition: The relative difference between the angular distribution for forward and backward scattering.

$$\Sigma = (d\sigma_F - d\sigma_B)/(d\sigma_F + d\sigma_B)$$

The angles are given as ANG1 and ANG2.

5. Mass ratios

For photofission, the fission fragment yields may be presented as a function of the ratio of the masses of the fission fragments (see M0135). We propose to add the data heading MASS-RATIO to Dictionary 24 for these cases.

6. High- and Low-Energy Components of Cross Section

In the evaluation of photonuclear data the cross section is often presented for a "high-energy" and "low-energy" component of the secondary particle spectrum (see data set M0140). These are the lower and higher components of the so-called configurational splitting of the giant dipole resonance observed in light and medium nuclei. Both are the sum of the cross sections for a number of different reactions with different outgoing particle energies. The difference between the centers of gravity of two such components defines the energy value for configurational splitting.

We propose the addition of the branch codes 'HEN' and 'LEN' to cover these cases. (The addition of the code 'PAR' is not appropriate, since no secondary energy is given.)

a. High-energy component of Cross Section

REACTION Coding: (---(G,ABS),HEN,SIG)

Definition: The high-energy component of the total photoabsorption cross section due to the nucleon transitions from the lower filled shells of the nucleus to unfilled valence shells. (The contributing reactions may be defined in free text.)

b. Low-energy component of Cross Section

REACTION Coding: (---(G,ABS),LEN,SIG)

Definition: The low-energy component of the total photoabsorption cross section due to the nucleon transitions from the unfilled valence shell of the nucleus to various empty upper shells. (The contributing reactions may be defined in free text.)

7. Analysis

In addition to adding codes to Dictionary 23 to specify the type of analysis used to analyze the spectra measured, we would like to be able to code the energy step used in computer retrievable form. We suggest, as an alternate to adding the energy step as a second field under ANALYSIS, the addition of the data heading 'ANAL-STEP'.

Example:
ANALYSIS (PLA) Penfold-Leiss analysis using an energy step of 0.5 MeV.

COMMON
ANAL-STEP
MEV
0.5
ENDCOMMON

8. Incident source

There are many reactions used as "monoenergetic" photon sources. We would like to be able to specify these reactions without having to increase the size of Dictionary 19 unnecessarily. Therefore, we propose the following change in the coding rules for INS-SOURCE.

For monoenergetic photons, the code MPH= will be followed by the source reaction, coded as for REACTION. The reaction code will be enclosed in parentheses.

Example: INC-SOURCE (MPH=(24-CR-52(N,G)24-CR-53))

Following is a proposed LEXFOR entry for Incident Photon Sources.

There are three main types of incident photon sources: Bremsstrahlung spectrum, Quasimonoenergetic, and Monoenergetic. Definitions and coding formats are given below for these spectra and their variations.

Bremsstrahlung Spectrum. "Whole" or "white" bremsstrahlung radiation spectrum.

INC-SOURCE (BRST)

Hardened Bremsstrahlung Spectrum. Modification of "whole" spectrum by filtering through special scatterers (light nuclei materials: paraffin, carbon, *etc.*

INC-SOURCE (BRST,HARD)

Difference Spectrum. The difference between two Bremsstrahlung spectra with close end points.

INC-SOURCE (BRST,DIFFR)

Annihilation Radiation Spectrum. Quasimonoenergetic radiation obtained from the in-flight annihilation of fast positrons, subtracting the bremsstrahlung from electrons.

INC-SOURCE (QMPH,ARAD)

Tagged Photon Spectrum. Quasimonoenergetic radiation obtained by measuring the scattered electron energy in coincidence with the photons produced.

INC-SOURCE (QMPH,TAGD)

Kinematically Determined Photon Spectrum. Quasimonoenergetic radiation energy determined using energy and impulse measurements of reaction products with full reaction kinematics.

INC-SOURCE (QMPH,KINDT)

Threshold Determined Photon Spectrum. Quasimonoenegetic radiation energy determined using the one-to-one correspondence between the energy of the photoparticle and that of the incident photons in the energy range above the reaction threshold, but below the threshold for the first excited state.

INC-SOURCE (QMPH,THRDT)

Monoenergetic Radiation from Radiative Capture. Radiation from radioactive product nucleus of a radiative cature reaction.

INC-SOURCE (MPH=reaction) Coded as for REACTION sf1 - sf4.

Monoenergetic Radiation from Laser scattering. Radiation produced by backward scattering of laser light on fast electrons.

INC-SOURCE (MPH,LASER)

Monoenergetic Radiation from Compton Scattering. Radiation from product nucleus of a radiative capture reaction for which energy is smoothly varied using the effect of Compton scattering.

INC-SOURCE (MPH,COMPT)

9. Incident Spectrum

We would like to add an additional code to SF8 to distinguish between data for a broad bremsstrahlung spectrum, and those data obtained from an unfolding analysis, which are for a narrower range of spectrum energies (typically 100 to 500 keV, see **7. Analysis**).

We propose the following:

BRA	average over part of bremsstrahlung spectrum The energy will, typically, be coded as EN-MEAN, or, occasionally, as EN-MIN or EN-MAX.
BRS	bremsstrahlung spectrum average The energy will be coded under EN-MAX.

10. Fitting Coefficients

We would like to add the REACTION modifier code CS2 for coefficients obtained by fitting an angular distribution by an equation of the form:

$$A + B \sin^2\theta + C \sin^2\theta \cos\theta + D \sin^2\theta \cos^2\theta$$

where A is the isotropic term
B is the dipole contribution term
C is the interference term of B and C
D is the quadrupole contribution term

The coefficients would be coded in the usual way with the coefficient being assigned as A = 0, B = 1, *etc.*

Reaction coding: (---------,,DA,,CS2)

Note: The first and second terms are identical to a sine^2 expansion.

11. Particle designator codes in Dictionary 36

Concerning the comment on particle designator codes in Dictionary 36 in Memo CP-D/215, we suggest that no entry should be required for the particle designator field. All entries in Dictionary 36 for such codes would be removed. All codes from Dictionary 33 and those from Dictionary 27 which have a '3' or a 'Z' in column 15 would be legal for this field.

Assuming that the above is acceptable, the following have been removed from our list of additions.

,COR,N/D	NO	angular correlation neutrons/deuterons
,COR,N/P	NO	angular correlation neutrons/protons
,COR,P/D	NO	angular correlation protons/deuterons
,DA,A,LEG	DA	Legendre coeff. for ang. distrib. of alphas
,DA,A,LEG/RS	DA	Legendre coeff. for 4pi*ang. distrib. of alphas
,DA,P,4PI	B	angular distribution of protons * 4 pi
,DA,RSD	DA	angular distribution of residual nucleus
,DA/TYA,P	DA	Treiman-Yang angular distribution for plane defined by product nucleus and outgoing proton
,DE,A/RSD	DE	energy spectrum of alpha/residual nucleus pair
,DE,N/D	DE	energy spectrum of neutron/deuteron pair
,DE,N/P	DE	energy spectrum of neutron/proton pair
,DE,P/A	DE	energy spectrum of proton/alpha pair
,DE,P/D	DE	energy spectrum of proton/deuteron pair
,DE,P/RSD	DE	energy spectrum of proton/residual nucleus pair
PAR,DA,N/P	DA	partial angular distribution of neutron/proton pair
PAR,MCO,N/P	DA	partial linear momentum correlation of neutron/proton pair
PAR,SIG,D	B	partial cross section for deuterons
PAR,SIG,P/T	B	partial cross section for proton/triton pair

12. Dictionary Update

Additional codes are included.

Add to Dictionary 18 (Facility)

ESTRG	ELECTRON STORAGE RING

Add to Dictionary 19 (Incident source)

ARAD	ANNIHILATION RADIATION
COMPT	COMPTON SCATTERING
HARD	HARDENED
KINDT	KINEMATICALLY DETERMINED
LASER	LASER SCATTERING
MPH=	MONOENERGETIC PHOTON REACTION =
TAGD	ELECTRON TAGGED
THRDT	DETERMINED BY THRESHOLD TECHNIQUE

Add to Dictionary 21 (Method)

RINGR	RING RATIO METHOD
STATD	STATISTICALLY DETERMINED

Add to Dictionary 22 (Detector)

CEREN	CERENKOV DETECTOR
HE3SP	HE-3 SPECTROMETER

Add to Dictionary 23 (Analysis)

DIFFR	DIFFERENCE SPECTRUM
DTBAL	DETAILED BALANCE (FOR ANALYSIS OF INVERSE REACTIONS)
LEAST	LEAST STRUCTURE METHOD
PHDIF	PHOTON DIFFERENCE
PLA	PENFOLD-LEISS METHOD
REDUC	REDUCTION METHOD
REGUL	REGULARIZATION METHOD
THIES	THIES'S METHOD
UNFLD	UNFOLDING PROCEDURE

Add to Dictionary 24 (Data Headings)

ANAL-STEP	Energy step used in analysis	
ANG1-CM	Angle in c.m. system, definition specified in BIB-section	G
ANG2-ERR	Angle error, definition specified in BIB section	H
E-MEAN	Mean energy of outgoing particle, lab system	E
E1-CM	Energy of outgoing particle, c.m.system, defined in BIB section	E
MASS-RATIO	Ratio of atomic masses of fission fragments	J
MASS1-MAX	Maximum atomic mass of first fission fragment	J
MASS2-MIN	Minimum atomic mass of second fission fragment	J
POLAR	Electric or magnetic polarity	E

Add to Dictionary 31 (Branch):

EP	for a given electric polarity component
HEN	high-energy component
LEN	low-energy component
MP	for a given magnetic polarity component

Add to Dictionary 32 (Parameter)

TYA	Differential with respect to Treiman-Yang angle

Modify Dictionary 34 (Modifiers)

ASY	Asymmetry
BRA	Average over part of bremsstrahlung spectrum
BRS	Bremsstrahlung spectrum average
CS2	Modifier for fitting coefficients of the form $A + B\sin^2\theta + C\sin^2\theta\cos\theta + D\sin^2\theta\cos^2\theta$
FB	Modifier for foreward-to-backward assymetry
PP	Modifier for assymetry as relative difference for incident radiation with polarization vector perpendicular and parallel to the reaction plane