DAT/324-0

BROOKHAVEN NATIONAL LABORATORY

MEMORANDUM

CP-C/93

82/04/19

REGISTRY SERVICES
ORIGINAL FORWARDED TO:
J. J. Schmidt + encl
FOR ACTION
cc:

DATE: April 7, 1982

TO: Distribution

FROM: V. McLane

SUBJECT: Polarization

Enclosed is the proposed revision of the LEXFOR entry on Polarization. As suggested by Hans Lemmel, only those quantitites for which data has been encounted are entered in the coding section.

Additional codes required are as follows:

Dictionary 19	(Source of Incident Particles)
POLTR	Polarized target
ATOMIC	Atomic beam source
LAMB	Lamb-shift source
Dictionary 24	(Data-Heading Keywords)
POL-BM	Beam polarization
POL-BM-ERR	Beam polarization error
POL-TR	Target polarization
POL-TR-ERR	Target polarization error
Dictionary 34	(Modifiers)
AYY	Spin-correlation function, outgoing particle spins normal to scattering plane
ANA	Analyzing power
Dictionary 36	(Quantities)
,POL/DA,,AYY	NO (SPIN-CORRELATION OF POLARIZED PARTICLES)
,POL/DA,,ANA	NO (ANALYZING POWER)

Sol Pearlstein

VM:jb

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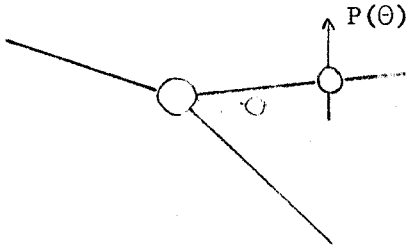
Polarization

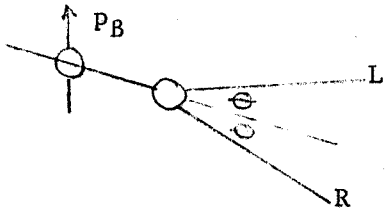
The following definitions and coding rules are given for spin-1/2 particles. Cartesian notation is used. Definitions will be added for spin-1 particles as the need arises.

Definitions

Under the influence of a spin-orbit force, an unpolarized beam of particles becomes at least partially polarized (i.e., the particles acquire a preferred spin).



The inverse of this situation is the asymmetric scattering of a polarized beam of particles. The degree of polarization of such a beam may be determined by measuring the left-right asymmetry upon scattering from a target nucleus which plays the role of an Analyzer.



$$e = L-R/L+R = p_B A_Y$$

where e = asymmetry
P_B = polarization of incident particle beam
A_Y = analyzing power
L,R = intensity of particles scattered right and left in the same plane under the same angle

The principle of Polarization-Asymmetry Equality states that, for time-reversal invariant reactions, the polarization induced in a previously completely unpolarized beam by elastic scattering from spin-zero nuclei is identically equal to the asymmetry ensuing from the scattering of a perfectly polarized beam under the same conditions.

Basel (sign) Convention for spin-1/2 Particles

In nuclear interactions the positive polarization of particles with spin 1/2 is taken in the direction of the vector product k(i) x k(o), where k(i) and k(o) are circular wave vectors of the incoming and outgoing particles respectively.

See Reference 1 for more detail.

Madison Convention

The state of spin orientation of an assembly of particles, referred to as polarization, should be denoted by the symbols t(kq) (spherical) or p(i),p(ij) (Cartesian).

These quantities should be referred to a right-handed coordinate system in which the positive z-axis is along the direction of momentum of the particles, and the positive y-axis is along k(i) x k(o) for the nuclear reaction which the polarized particles initiate, or from which they emerge.

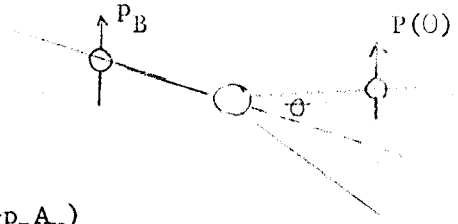
Terms used to describe the effect of initial polarization of a scatterer on the differential cross section for a nuclear reaction (referred to as analyzing power) should include the modifiers analyzing or efficiency. These quantities should be referred to a right-handed coordinate system in which the positive z-axis is along the beam direction of the incident particles and the y-axis is along k(i) x k(o) for the reaction in question.

In the expression for a nuclear reaction A(b,c)D, an arrow placed over the symbol denotes a particle which is initially in a polarized state or whose state of polarization is measured.

Example: $A(b,\vec{c})D$; polarization is measured for a particle c emerging from a reaction between unpolarized particles A and b.

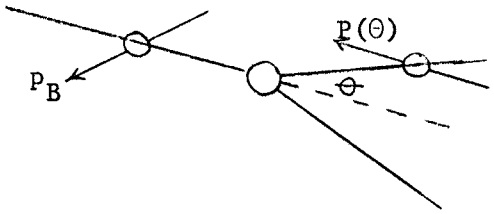
See Reference 2 for more details.

Depolarization Parameter (D): change in polarization due to scattering.



$$P(\Theta)=(A_Y+Dp_B)/(1+p_BA_Y)$$

Rotation Parameter: measure of rotation of spin of scattered beam



$$R=\frac{P(\Theta)}{P_B}$$

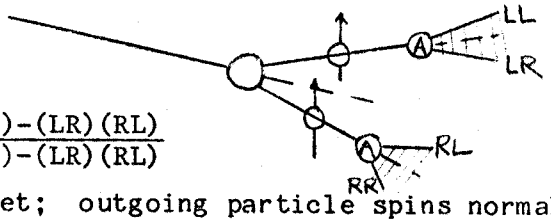
Differential polarization:

$$I_p=I_oP(\Theta)$$

where I_o = differential cross section for an unpolarized beam

Spin-Correlation Parameters

C_{NN}: unpolarized beam; unpolarized target; outgoing particle spins normal to scattering plane; outgoing particles scattered right and left analyzed.



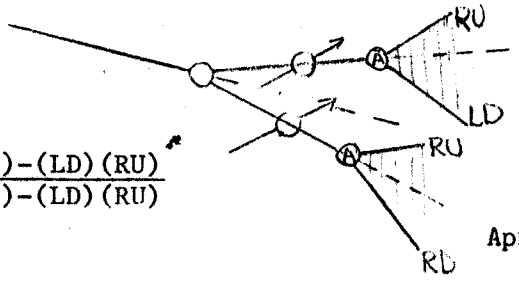
$$C_{NN}=\frac{1}{A_Y2}\frac{(LL)(RL)+(LR)(RR)-(LL)(RR)-(LR)(RL)}{(LL)(RL)+(LR)(RR)+(LL)(RR)-(LR)(RL)}$$

A_{YY} : polarized beam; polarized target; outgoing particle spins normal to scattering plane; asymmetry is measured.

$$e=|p_b||p_t|A_{YY}$$

If time reversal holds: $C_{NN}=A_{YY}$

C_{kp}: unpolarized beam; polarized target; outgoing particle spins in scattering plane.



$$C_{kp}=\frac{1}{A_Y2}\frac{(LU)(RU)+(LD)(RD)-(LU)(RD)-(LD)(RU)}{(LU)(RU)+(LD)(RD)+(LU)(RD)-(LD)(RU)}$$

References

1. "Proceedings of the International Symposium on Polarization Phenomena of Nucleons", P.Huber and K.P.Meyer, eds. Helvetica Phys.Acta, Suppl. VI (1961)

2. "Polarization Phenomena in Nuclear Reactions", page xxv, H.H.Barschall and W.Haeberli, eds. The University of Wisconsin Press, Madison (1971)

3. "Polarization Phenomena in Nuclear Physics - 1980", G.G.Ohlsen, R.E.Brown, N.Jarmie, W.W.McNaughton, G.M.Hale, eds., American Institute of Physics (1981).

4. W.Larkin, Phys. Rev. 98, 139 (1955)

5. L.J.B.Goldfarb, Nuclear Phys. 7, 622 (1958)

6. A.Simon, Phys. Rev. 92, 1050 (1953)

7. "Physics of Nuclei and Particles", Vol. II, Ch. 13, P.Marmier and E.Sheldon, Academic Press, 1970.

8. "Polarization of Fast Neutrons", L.Wolfenstein, Annual Review of Nuclear Science 6, 43 (1956)

9. "Nucleon-Nucleon Experiments", J.C.Hopkins, LA-DC-10061 (1968).

Coding

The sign should follow the "Basel" or "Madison" Convention.

The following quantities are coded in EXFOR:

- The spin-polarization probability, integrated over all pertinent angles is coded with 'POL' in REACTION SF6.

- The differential spin-polarization probability with respect to angle of emmission is coded with 'POL/DA' in REACTION SF6.

- The asymmetry is coded with 'POL/DA' in REACTION SF6 and 'ASY' in SF8.

- The analyzing power is coded with 'POL/DA' in REACTION SF6 and 'ANA' in SF8.

- The spin-correlation parameter (A_{YY}), is coded with 'POL/DA' in REACTION SF6 and 'AYY' in SF8.

The data units should be coded as 'NO-DIM'.

Data are assumed to be in Cartesian Coordinates. (Coding rules for data in spherical coordinates should be propsed as the need arises.)

Polarized incident-projectile source

Entries should be made under the Information-Identifier Keyword N-SOURCE for the following cases:

- A polarized neutron source is entered using the code 'POLNS'.

- A polarized target is entered using the code 'POLTR'.

- An atomic beam source is entered using the code 'ATOMIC'.

- A Lamb-shift source is entered using the code 'LAMB'.

The incident-projectile source should be coded in sufficient detail to describe the reaction. The polarization of the beam and target should be given in the data table, if known, using the data headings POL-BM and POL-TR, respectively.

Example:

N-SOURCE (POLTR,LAMB) Polarized target and Lamb-shift ion source