PROJECTION OPERATOR FOR CHANNEL SELECTION IN NUCLEAR REACTIONS

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Abstract: The projection operator capable of selecting specified states of total angular momentum (Isospin) in reactions involving particles with arbitrary spins (isospins) is presented.

In view of the considerable progress made in producing polarized beams and targets with spin > \( \frac{1}{2} \), it is of interest to consider the spin structure of the reaction amplitude for \( a + b \rightarrow c + d \) with arbitrary spins \( s_a, s_b, s_c, s_d \) respectively. Blatt and Biedenharn/1/ have outlined a general method of phase shift analysis for particles with arbitrary spins. In the well-known case of NN scattering, itself, the connection between the Wolfenstein/2/ amplitudes and the phase shifts is highly involved /3/ and consequently the emphasis has shifted to determine directly the amplitudes from experiments/4/. In simple cases like \( \pi - N \) scattering the channel selection with well defined total angular momentum \( J \) or isospin \( I \) is elegantly achieved through the use of appropriate projection operators/5/. So also in the case for singlet and triplet states of spin (or isospin) in N-N scattering. Such a technique for higher spins when the resulting angular momentum channels number more than 2 appear to be unknown. We present here the answer to this basic problem.

Consider in general a situation where a system consists of two angular momenta \( j_1 \) and \( j_2 \), the projection operator \( \Pi_j(j_1, j_2) \) for the total angular momentum \( j \) is obtained in the form

\[
\Pi_j(j_1, j_2) = \sum_k (T^k(j_1).T^k(j_2)) (-)^{j_1+j_2-j} [j] \quad (1)
\]

where the summation over \( k \) extends from 0 to \( 2j_2 \).
if we make the convention to denote the smaller of the two angular momenta by $j_2$, and $T^k_q(j)$ are irreducible tensor operators constructed out of the angular momentum operator $J$ and is normalised through

$$\langle jm' | T^k_q(j) | jm \rangle = C(kj;jm') / k^j$$

(2)

It is readily seen that (1) will reduce in special cases to the well known projection operators. Moreover, it is obvious that $\pi_j(1,s) \pi_s(s_1,s_2)$ is the projection operator for channel selection with total angular momentum $j$ when particles with spin $s_1$ and $s_2$ have relative orbital angular momentum $l$.

It is also obvious that (1) is adequate to handle isospin projection.

References

/1/ J.M. Blatt and L.C. Biedenharn, Revs. Mod. Phy. 24, 258 (1952)
/2/ L. Wolfenstein, Ann. Rev. Nucl. Sc. 6, 43 (1956)
G. Hohler et al., Handbook of Pion-Nucleon Scattering, Karlsruhe (1979).