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EXTREME VALUES OF THE ANALYZING POWER FOR SPIN-1 POLARIZATION

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EXTREME VALUES OF THE ANALYZING POWER FOR SPIN-1 POLARIZATION*

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The large experimental values of the components A_y and A_{yy} of the analyzing power for deuterons in several processes suggest the possibility of extreme values $A_y = \pm 1$ and $A_{yy} = 1$. Criteria to judge maximum possible polarization states for an ensemble of polarized spin-1 particles produced in a nuclear reaction have been given by Lakin[1)] and Minnaert[2)]. They are based on the fact that the density matrix is positive semidefinite. Its expansion in terms of tensor operators τ_{kq} imposes conditions on the tensor moments t_{kq}. Due to time reversal invariance, identical limitations apply for the polarization efficiencies T_{kq}. They are particularly simple in a transverse coordinate system S' with the z'-axis perpendicular to the reaction plane.

$$\delta^2 = \frac{1}{2}\left[(T'_{10})^2 + (T'_{20})^2 + 2|T'_{22}|^2\right] \leqslant 1. \qquad (1)$$

$$\varepsilon^2 = (T'_{20} + \sqrt{2})^2 - 3(T'_{10})^2 - 6|T'_{22}|^2 \geqslant 0. \qquad (2)$$

The observables T'_{kq} in terms of those defined by the Madison Convention are

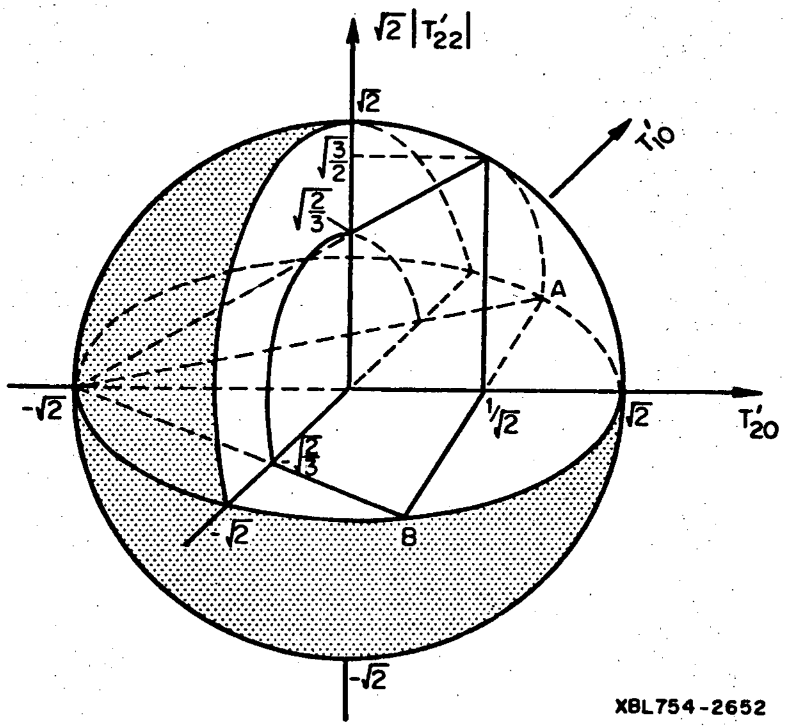
$$\begin{aligned} T'_{10} &= \sqrt{2}\, iT_{11} = \frac{1}{2}\sqrt{6}\, A_y, \\ T'_{20} &= -\frac{1}{2}(T_{20} + \sqrt{6}\, T_{22}) = \frac{1}{2}\sqrt{2}\, A_{yy}, \\ T'_{22} &= \frac{1}{4}(\sqrt{6}\, T_{20} - 2T_{22}) - iT_{21} = \frac{1}{6}\sqrt{3}\,[(A_{zz}-A_{xx}) + i2A_{xz}]. \end{aligned} \qquad (3)$$

In the space $(T'_{10}, \sqrt{2}|T'_{22}|, T'_{20})$, $\delta = 1$ defines a sphere and $\varepsilon = 0$ an inscribed cone (figure). Points with $A_{yy} = 1$ lie on the base of the Lakin cone ($T'_{20} = 1/2\sqrt{2}$). Only there, values of $A_y = \pm 1$ can be attained (points A and B), and then only if $|T'_{22}| = 0$. Thus

$$A_{yy} = 1, \quad A_{xx} = A_{zz} = -\frac{1}{2}, \quad A_{xz} = 0. \qquad (4)$$

Consequently $A_{yy} = 1$ is a prerequisite for $A_y = \pm 1$, and the other efficiencies are numerically determined. This was shown for $^4He(\vec{d},d)^4He$ by Grüebler et al.[3)], using the properties of that particular M-matrix. From the derivation here, it is obvious that eqs.(4) are always valid. In several reactions, regions with large values of A_y have been found[4)], where eqs. (4) are nearly satisfied, but the data density is not good enough to allow any conclusions. Also eqs. (4) are necessary but not sufficient conditions for $A_y = \pm 1$, since they are satisfied by any point on the line AB. In order to prove the existence of any extreme value, the fulfillment of the relevant conditions on the M-matrix has to be established. However these conditions, given for several reactions in papers contributed to this conference, are not necessarily independent. For $A_y = \pm 1$ for instance, eq. (2) for $\varepsilon^2 = 0$ directly imposes the requirement $A_{yy} = 1$.

It also should be noted that it is the direction perpendicular to the scattering plane (y-axis) which yields the large values of the analyzing power. The Madison Convention, generally used for the description of both the M-matrix and the experimental data, does not use this preferred direction as the quantization axis. An investigation of the conditions on the M-matrix in a transverse coordinate system is in progress.



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