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SPIN SELF-ANALYSIS OF PHOTOPRODUCED MESON AND BARYON RESONANCES *

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Spin-1 mesons are self-analyzing with respect to their tensor polarization, and spin-2 mesons are self-analyzing with respect to their rank-2 and their rank-4 polarization. Also spin-$^3/_2$ baryons are self-analyzing with respect to their rank-2 polarization. These properties make, for example, spin-correlations involving the vector-meson's vector polarization inaccessible directly with present experimental techniques.

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Precision experiments for vector-meson photoproduction, including coincidence measurements of the vector-meson's decay products, are made possible by new high-flux, continuous beams of polarized electrons or photons on polarized targets, along with large-angle spectrometers and recoil polarimeters. An example of such a reaction is

$$\vec{\gamma} + \vec{N} \to \vec{\phi} + \vec{N}' \,. \tag{1}$$

At the same time, one can consider the photoproduction of tensor mesons such as

$$\vec{\gamma} + \vec{N} \to \vec{f}_2 + \vec{N}' \,, \tag{2}$$

as well as the photoproduction of baryon resonances such as

$$\vec{\gamma} + \vec{N} \to \vec{\Delta} + \pi. \tag{3}$$

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Spin observables involving the polarization of meson or baryon resonances are now experimentally accessible by measuring the angular distribution of the decay products of these resonances in photoproduction or electroproduction. Recent production models provide predictions for these spin observables which when compared to data should serve as an important test of our understanding of these processes [1].

In this short paper, we concentrate on spin observables in photoproduction of vector-mesons. At the end of the paper the obtained conclusions will be extended to the photoproduction of tensor-mesons as well as to the photoproduction of spin-$^3/_2$ baryon resonances. For vector-mesons, which have spin 1, the spin observables [2] include correlations involving either the vector meson's vector polarization or its tensor polarization. Single spin observables include the vector polarization P_y^V and the three tensor polarizations T_{20}^V, T_{21}^V, and T_{22}^V.

In the case of a polarized photon beam in the $\vec{x}, \vec{y}$, or $\vec{z}$ direction the 5 non-zero correlations between the photon polarization and the vector-meson vector polarization are $C_{xy}^{\gamma V}, C_{yx}^{\gamma V}, C_{yz}^{\gamma V}, C_{zx}^{\gamma V}, C_{zz}^{\gamma V}$. There are also 7 non-zero correlations of the photon polarization and the vector-meson tensor polarization; namely, $C_{x20}^{\gamma V}, C_{x21}^{\gamma V}, C_{x22}^{\gamma V}, C_{y21}^{\gamma V}, C_{y22}^{\gamma V}, C_{z21}^{\gamma V}, C_{z22}^{\gamma V}$.

Due to angular momentum symmetry, the angular distribution of parity conserving vector meson decay depends on the meson's tensor polarization, but not on its vector polarization. [1] Therefore, measuring the angular distribution of mesonic decay products (or leptonic decay products) of the vector-meson gives information about its tensor polarization, but not its vector polarization. It is in principle possible to access the vector-meson's vector polarization from its leptonic decay, but for that purpose one needs to measure the spin of decay leptons, which is not practical with present experimental techniques. Another possible way to access the vector polarization would be to relate the vector-meson's vector polarization to other accessible spin observables [3]. Another alternative would be to exploit the interference with background processes to extract information about the vector polarization. This last method however would necessarily be model dependent. As a result of these considerations, spin observables involving the vector polarization of the vector-meson are not directly accessible with present experimental techniques.

Further double spin observables include the case of a polarized nucleon target. There are 5 non-zero correlations between the target polarization and the vector-meson vector polarization $C_{xx}^{NV}, C_{xz}^{NV}, C_{yy}^{NV}, C_{zx}^{NV}, C_{zz}^{NV}$, and 7 non-zero correlations between the target polarization and the vector-meson tensor polarization; namely, $C_{x21}^{NV}, C_{x22}^{NV}, C_{y20}^{NV}, C_{y21}^{NV}, C_{y22}^{NV}, C_{z21}^{NV}, C_{z22}^{NV}$. Again

[1] See our recent preprint [4] for the proof.

in this case the 5 correlations with the vector polarization are not directly accessible from the decay angular distribution. For a polarized recoil nucleon, the conclusions are identical as for the polarized nucleon target, and we will therefore not repeat the list of observables for that case. Similar conclusions can be obtained for triple and quadruple spin correlations.

The same considerations imply that spin-2 mesons with parity conserving two-body decays are self-analyzing with respect to their rank-2 and rank-4 tensor polarization and do not reveal their vector or octupole polarizations via the angular distributions of their decay products. Also, spin-$^3/_2$ baryon resonances with parity conserving two-particle decay modes, are self-analyzing only with respect to their rank-2 polarization.

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