

Spin Density Matrix Elements in exclusive production of ω and ϕ mesons at Hermes

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Spin-density matrix elements SDMEs describe the distribution of final spin states of the produced vector meson. These elements depend on helicity amplitudes for the angle and momentum dependent transition process between initial spin states of the virtual photon and final spin of the produced vector meson. The values of SDMEs can serve to establish the hierarchy of the helicity amplitudes that are used to describe exclusive vector-meson production. They are also used to test s-channel helicity conservation (SCHC) hypothesis and to investigate contribution of unnatural parity exchange mechanism in vector meson production.

The HERMES experiment at DESY has measured SDMEs for both ω and ϕ mesons. The omega meson is observed in the following process with decay branching ratio $Br = 89.1\%$:

$$e + p \rightarrow e' + p' + \omega(\rightarrow \pi^+ \pi^- \pi^0(\rightarrow (2\gamma))),$$

while the ϕ meson is studied in the reaction :

$$e + p \rightarrow e' + p' + \phi(\rightarrow K^+ K^-)$$

The angular distribution in exclusive electroproduction of vector mesons on unpolarized targets depends on 23 SDMEs, 15 which do not depend on beam polarization and 8 which depend on beam polarization. The 23 SDMEs were extracted by fitting experimental angular distribution with theoretical angular distribution by likelihood method.

These SDMEs have been determined for exclusive ω meson production on Hydrogen and Deuterium targets, at HERMES kinematic region of $1.0 < Q^2 < 10.0 \text{ GeV}^2$ and $2.0 < W < 6.3 \text{ GeV}$ and $-t' < 0.2 \text{ GeV}^2$ and for ϕ meson at $1.0 < Q^2 < 7.0 \text{ GeV}^2$ and $2.0 < W < 6.3 \text{ GeV}$ and $-t' < 0.4 \text{ GeV}^2$.

The presentation of the extracted SDMEs is based on the hierarchy of Natural Parity Exchange (NPE) helicity amplitudes:

$$|T_{00}| \sim |T_{11}| \gg |T_{01}| > |T_{10}| \gtrsim |T_{1-1}|.$$

No s-channel Helicity Conservation (SCHC) violation is observed in exclusive ω and ϕ meson production. The comparison of ω and ρ^0 SDMEs and of the calculated value u_1 :

$$u_1 \equiv 1 - r_{00}^{04} + 2r_{1-1}^{04} - 2r_{11}^1 - 2r_{1-1}^1,$$

indicates large contribution of unnatural parity exchange amplitudes in exclusive ω meson production.