Near-threshold ω and ϕ production in pp and pd collisions and polarized intrinsic strangeness of the nucleon*

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It is well known (see e.g. [1] and references therein) that the ratio of the ϕ/ω yields where the initial and other final hadrons do not contain strange quarks, is a particularly sensitive probe of the OZI rule. At the standard deviation $\delta = \theta - \theta_{\rm i} = 3.7°$ from the ideal mixing angle $\theta_{\rm i} = 35.3°$ degrees we have $R/f = 4.2 \times 10^{-3}$, where f is the ratio of the phase space factors. However, the existing experimental data show an apparent excess of R/f above the standard value.

In Ref. [1] the large excess of R in pp and p$\bar{\rm p}$ collisions over the prediction by the OZI rule was explained as an effect of intrinsic s$\bar{\rm s}$ component in the nucleon wave function. Moreover Ellis et al. [2] argued that the dominant contribution comes from the $^3P_0$ configuration with the total s$\bar{\rm s}$ spin negatively polarized with respect to the nucleon spin. Withing the framework of this polarized nuclear strangeness (PNS) model the ϕ production in NN collisions depends on the spin of the initial state: it is more abundant in $S_i = 1$ state, than in $S_i = 0$ state. To test this prediction, the reaction pp $\to$ ppϕ using polarized beam and polarized target, was discussed in Refs.[3, 4]. Here we consider another possibility to check the PNS model in the near-threshold ω and ϕ production in *pp* and *pn* collisions using an unpolarized beam and unpolarized target.

Let us consider the reactions pp $\to$ ppω (a), pn $\to$ dω (b), pp $\to$ ppϕ (c) and pn $\to$ dϕ (d) near the corresponding thresholds (i.e. at the same c.m. energy release Q). It is essential that the isospin of the initial and final states is fixed for all these reactions: $I_i = I_f = 1$ for reactions a) and c) and $I_i = I_f = 0$ for b) and d). At Q below $50 - 60$ MeV one expects the dominant role of the S-wave contributions to the final states and, therefore, the initial spin states of the reactions (a)–(d) will be fixed by spin and parity conservation arguments: $S_i = 1$ for reactions (a) and (c) and $S_i = 0$ for (b) and (d). It means that the cross section ratios

$$R_{\rm ca} = \sigma({\rm pp} \to {\rm pp}\phi)/\sigma({\rm pp} \to {\rm pp}\omega) \qquad (1)$$

and

$$R_{\rm db} = \sigma({\rm pn} \to {\rm d}\phi)/\sigma({\rm pn} \to {\rm d}\omega) \qquad (2)$$

(measured at the same Q) will contain the information equivalent to polarization experiments. According to the PNS model the relative production of ϕ is expected to be more pronounced in the reaction pp $\to$ ppV than in pn $\to$ dV, i.e. $R = R_{\rm ca}/R_{\rm db} \gg 1$. Hence, comparing the experimental ratio of the ϕ/ω yields in pp and pn collisions $R_{\rm exp} = R_{\rm ca}^{\rm exp}/R_{\rm db}^{\rm exp}$ with theoretical predictions, based on PNS model $R_{\rm theor} \gg 1$, will allow us to obtain new information on the nature of the OZI rule violation.

According to existing experimental data on ω and ϕ production in pp collisions $R_{\rm ca} = (49 \pm 26) \times 10^{-3}$ (See [5]). There are no data on ω and ϕ production in the pn $\to$ dM reaction. Using the two-step model which is described by triangle graphs with π-, ρ- and ω-meson exchanges the pn $\to$ dM cross section was calculated in [6] close to threshold for $M = \omega$, ϕ. The predicted cross section of the reaction pn $\to$ dω is found to be significantly larger than the the cross section of the reaction pp $\to$ ppω at $Q \leq 50$ MeV. The same is expected in the case of ϕ production. The ratio $R_{\rm db}$ was found to be $R_{\rm db} = (34 \pm 10) \times 10^{-3}$. According to results of model calculations presented in [7] one can obtain $R_{\rm db} = (9 \div 24) \times 10^{-3}$ at $Q =$ 30 MeV.

In comparison with the earlier measurements the study of ω- and ϕ-mesons production in the reactions (a–c) at COSY has the following advantages:

i) Since all the reactions will be studied at the same Q (c.m. energy release) the OZI violation parameter can be determined through the cross section ratios without introducing any phase-space corrections.

ii) At ANKE the ϕ-meson production can be detected via its decay into a K^+K^--pair.

iii) The deuteron in the final state is preferable to proton-neutron because of the large two-body phase space near threshold and because of the higher detection efficiency.

Note that the experiments on the ω- and ϕ-meson production in the reactions (b) and (d) at ANKE are forseen by the COSY proposal No.75 [8] and analysis of the first data on the reaction (b) at $T_{\rm p} = 2$ GeV is already in progress.

References:

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