Investigation of the ϕ-meson production in pp and pn collisions at ANKE

M. Hartmann, R. Koch, Y. Maeda, J. Haidenbauer, A.A. Sibirtsev

The Okubo-Zweig-Iizuka (OZI) rule states that processes with disconnected quark lines in the initial or final state are suppressed. Accordingly, the production of ϕ-mesons from initial non-strange states is expected to be substantially suppressed relative to the ω-meson production. The cross-section ratio for ϕ- and ω-meson production under similar kinematical conditions should then be in the order of $\sigma_\phi/\sigma_\omega \cong R = \tan^2\alpha_V = 4.2\times10^{-3}$ [1, 2], where $\alpha_V = 3.7°$ is the deviation from the ideal $\phi-\omega$ mixing angle [3]. However, existing experimental data show an apparent excess of the cross-section ratio over the OZI estimation R and thus indicate a possible violation of the OZI rule. This could be due to an intrinsic $s\bar{s}$ component in the nucleon, which would manifest itself in a ϕ production cross section significantly exceeding the limits given by the OZI rule.

Data on the reaction $\bar{p}p\to\phi\pi^0$ from the LEAR facility show a strong dependence on the initial spin state of the proton-antiproton system. Specifically the production rate from the spin-triplet state is 15 times larger than the one from the spin-singlet state [4]. It has been argued that the larger production rate of the spin-triplet state can be explained by a negatively polarized intrinsic $s\bar{s}$ component in the nucleons through a *rearrangement* process [5]. Such a situation could also occur in the ϕ-meson production in nucleon-nucleon collisions in the threshold region. In case of the reaction $pp\to pp\phi$ the entrance channel becomes a pure spin-triplet state close to threshold. Thus if the negatively polarized strangeness hypothesis is correct, the ϕ/ω ratio in pp collision should be increased.

There is only one experiment for $pp\to pp\phi$ at low excess energy (ε=83 MeV) and the reported ϕ/ω ratio is enhanced by about a factor 5 over the estimation from the OZI rule [6]. Furthermore, the fraction of initial spin-triplet states is only around 70$\sim$80% due to contributions from higher partial waves. Therefore, a measurement of the total cross section at excess energies much closer to threshold would be very useful to map out the energy dependence of the ϕ/ω ratio and, in particular, could provide important information about the origin of the strange sea quarks as well as the OZI violation.

In addition, the ϕ-meson production in pn collision, i.e. the reactions $pn\to pn\phi$ and $pn\to d\phi$, could also be sensitive to the intrinsic strangeness. Close to threshold the proton-neutron entrance channel contains both spin-triplet and spin-singlet channel whereas in $pn\to d\phi$ case only a spin-singlet state is present. Therefore, following the arguments of Ref. [5], a cross section ratio $\sigma_{pn\to pn\phi}/\sigma_{pp\to pp\phi}\approx0.5$ is expected and in addition $\sigma_{pn\to d\phi}/\sigma_{pp\to pp\phi}$ should be strongly suppressed according to the negatively polarized strangeness hypothesis. In contrast, meson exchange models predict $\sigma_{pn\to pn\phi}/\sigma_{pp\to pp\phi}\sim5$ [7] and also the ratio $\sigma_{pn\to d\phi}/\sigma_{pp\to pp\phi}$ was found to be sizable [8]. Experimental data on these ratios close to threshold would allow to discriminate between those theoretical models.

At the ANKE facility the measurement of the total cross section for $pp\to pp\phi$ will be carried out at the proton beam energies of 2.65 GeV(ε=18.5 MeV) and 2.70 GeV(ε=34.6 MeV). The energy dependence of the ϕ/ω ratio can then be obtained by utilizing available SPES-III results [9] of ω-meson production at comparable excess energies. The K^+K^- pair from the ϕ-meson decay is detected. Simulated invariant mass spectra of the K^+K^- system are shown in Fig.1. For details, see our proposal [10].

For ϕ-meson production in pn collision, the $pn\to d\phi$ reaction can be identified by detecting the fast deuteron in coincidence with the K^+K^- pairs from the ϕ decay using the deuterium target [11, 12, 13]. First measurements are foreseen at the end of 2002.

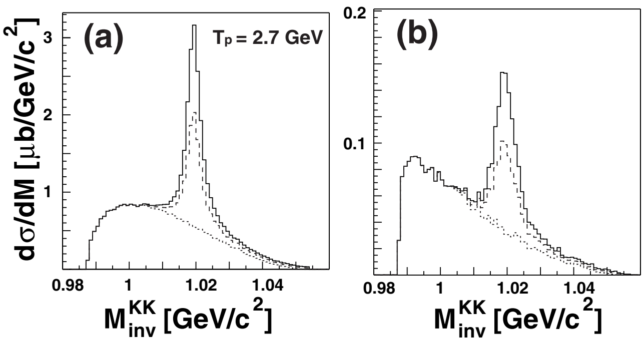

Fig. 1: Expected invariant spectra of the K^+K^- system at the beam energy of 2.70 GeV. The dotted lines show the contribution of the nonresonant process ($pp\to ppK^+K^-$). The solid and dashed lines show the total spectra with and without final-state interaction of protons, respectively. Figures (a) and (b) show the simulated result without and with the ANKE acceptance, respectively.

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