Vol. 31 (2000) ACTA PHYSICA POLONICA B No 10–11

PRODUCTION OF η, η', ω, ϕ AND a_0^+ MESONS IN REACTIONS $pn \to dM$ AND $pp \to da_0^+$ NEAR THE THRESHOLD*

V.Yu. Grishina

Institute for Nuclear Research
60th October Anniversary Prospect 7 A, 117312 Moscow, Russia
e-mail: grishina@cpc.inr.ac.ru

and L.A. Kondratyuk

Institute of Theoretical and Experimental Physics
B. Cheremushkinskaya 25, 117259 Moscow, Russia
e-mail: kondrat@heron.itep.ru

(Received June 2, 2000)

We discuss the near-threshold production of η, η', ω, ϕ and a_0^+ mesons in the reactions $pn \to dM$ and $pp \to da_0^+$. The two-step model can reasonably describe the η- meson production. The predictions for the cross sections of η', ω, ϕ and a_0^+ production demonstrate that those reactions can be detected at COSY (Jülich).

PACS numbers: 25.10.+s, 13.75.–n

Up to now most of measurements of the near-threshold meson production were done in pp-collisions. However, the corresponding meson production in pn is also quite interesting. It is known, for example, that the cross section of η-production in pn-collisions is essentially larger than that in pp-collisions. The reaction $pn \to d\eta$ is of special interest because the effect of ηd final state interaction (FSI) might clarify if the ηd bound state can exist. The same statement is also valid for the case of ω production in the reaction $pn \to d\omega$. The ratio of ϕ and ω yeilds in the reaction $pn \to dM$ is interesting from the point of view of the OZI-rule violation and possible admixture of the hidden strangeness in the nucleon. Threshold conditions fix the spin of the initial

* Presented at the Meson 2000, Sixth International Workshop on Production, Properties and Interaction of Mesons, Cracow, Poland, May 19–23, 2000.

state. For example, in the reacton $pn \to d\omega$ the spins of the initial nucleons are antiparallel ($s_{12} = 0$) and in the reaction $pp \to pp\omega$ they are parallel ($s_{12} = 1$). Therefore the unpolarized measurement of the $pp \to pp\omega$ and $pn \to d\omega$ cross sections near the threshold is equivalent to the use of polarized beam and polarized target. In the case of a_0-production the reaction $pp \to dM$ is the isospin filter for a final meson state. It makes possible to measure parameters of the charged a_0 meson which in contrast to a neutral a_0 mode can not be mixed with f_0. The reactions with a deuteron in a final state can be experimentally observed at ANKE spectrometer (COSY).

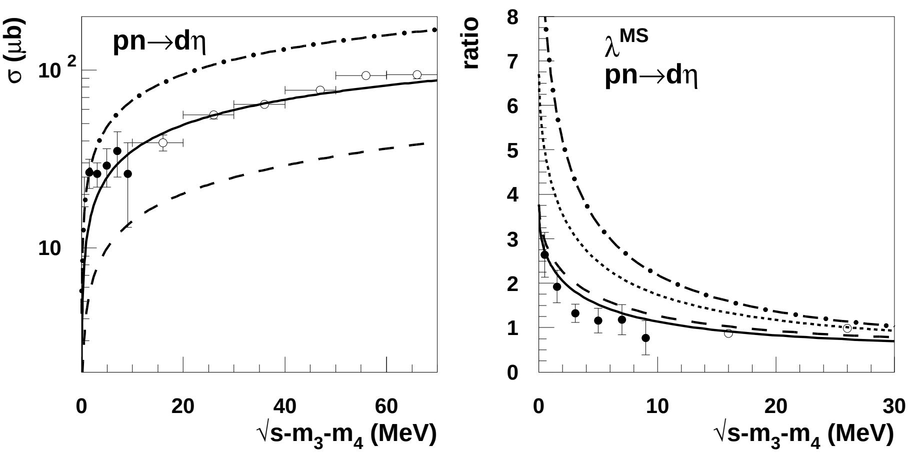

Fig. 1. (a) Cross section of the reaction $pn \to d\eta$ as a function of the c.m. excess energy. (b) Enhancement factors λ^{MS} resulting from different values of the ηN-scattering lengths as a function of the c.m. excess energy (the meanings of the curves as well as the data points in figures (a) and (b) are described in the main text).

Our report is based on the results of Refs [3–6], where the the cross sections of the reactions $pn \to dM$ were calculated using the two-step model (TSM). This model can be described by a triangle graph with π-, ρ- and ω-meson exchanges in the intermediate state. In Fig. 1(a) taken from [3] we present the total cross section of the $pn \to d\eta$ reaction as a function of the c.m. excess energy. The data points are taken from Refs. [1] (open circles) and [2] (filled circles). The dashed curve shows the result from the π-exchange contribution alone whereas the dash-dotted curve is the sum of π, ρ, and ω exchange. The solid curve represents the results including all contributions (π, ρ, ω) multiplied with a normalization factor $N = 0.52$. This factor which takes into account the initial state interactions was considered as free parameter. Very close to threshold we see the enhancement of experimental data over the theoretical curve. The enhancement factor λ^{MS}

is presented in Fig. 1(b) (taken from Ref. [3]) by black and empty circles. The points were calculated deviding experimental points by the theoretical values presented by the solid curve in the previous figure. To calculate $\lambda^{\rm MS}$ we used the Foldy–Brueckner adiabatic approach withing the multi-scattering theory. Different curves in Fig. 1(b) show the enhancement factor corresponding to different values of the η-nucleon scattering lengths. The solid curves corresponds to the ηN scattering length $a_{\eta N} = 0.291 + i\,0.360$ fm derived from η photoproduction data [7]. The dashed and dotted curves correspond to the values $a_{\eta N} = 0.3 + i\,0.3$ fm and $a_{\eta N} = 0.476 + i\,0.279$ fm proposed in Refs. [8] and [9], respectively. The dash-dotted curve is the result for $a_{\eta N} = 0.717 + i\,0.263$ fm, found in a recent analysis of Batinić *et al.* [10]. The best agreement with the data we have in the case of small scattering lengths extracted from the η meson photoproduction data.

Using TSM we have calculated also the cross sections of the reaction $pn \to dM$ for η', ω and ϕ production. When the S-wave gives dominant contribution and FSI is neglected the cross sections of the reactions $pn \to dM$ can be parametrized as follows

$$\sigma_{pn\to dM} \simeq D_M \sqrt{Q}. \tag{1}$$

Here $Q = \sqrt{s} - m_3 - m_4$ is c.m. excess energy in MeV. For η production the coefficient $D_\eta = 11\ \mu\text{b}/\sqrt{\text{MeV}}$ can be found from the fit to Uppsala data [1] and [2] at $Q \geq 10$ MeV. In the case of η', ω and ϕ production the TSM gives the following predictions $D_{\eta'} = 0.5 \pm 0.1\mu\text{b}/\sqrt{\text{MeV}}$, $D_\omega = 2.2 \pm 0.2\ \mu\text{b}/\sqrt{\text{MeV}}$, $D_\phi = 0.08 \pm 0.02\ \mu\text{b}/\sqrt{\text{MeV}}$. The ratio of the ϕ to ω yields is equal to $(34 \pm 10) \times 10^{-3}$. From the model for ω and ϕ production through combined $\pi - \rho$-exchange current we found that $D_\omega^{\pi-\rho} \simeq 1.51\ \mu\text{b}/\sqrt{\text{MeV}}$ and $D_\phi^{\pi-\rho} \simeq 0.025\ \mu\text{b}/\sqrt{\text{MeV}}$. So the ratio of ϕ and ω becomes about two times smaller than that obtained in the former model with the sum of independent π and ρ exchange contributions to $pn \to d\omega(\phi)$ cross section (see *e.g.* Ref. [5]). Note that in TSM the cross section for the reaction $pn \to d\eta'$ at $Q \simeq 30$ MeV should be about 1 μb or even more, and therefore should be measurable at new accelerator facilities such as COSY in Jülich.

In the case of a_0 production there are no experimental data on elementary $\pi N \to a_0 N$ amplitude near the threshold. Therefore we considered different possible mechanisms of $\pi N \to a_0 N$ transition. We found that the dominant contribution comes from the u-channel diagram [11]. The coupling constant $g_{a_0 NN} = 3.68$ is taken from paper [12]. All other contributions like t-channel diagrams with η and $f_1(1285)$-exchanges as well as s-channel contribution with intermediate nucleon were found to be smaller than u-channel term. The results of our calculations in the framework of TSM for the forward differential $pp \to da_0^+$ cross section as a function of proton laboratory momentum are presented in Fig. 2. The experimental points

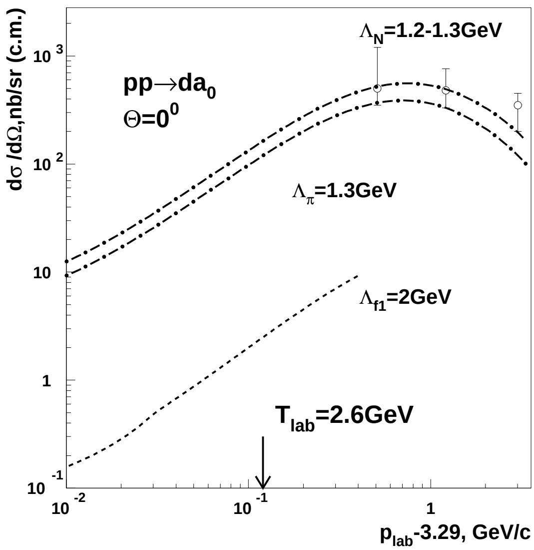

Fig. 2. Forward differential cross section of the reaction $pp \to da_0^+$ as a function of $(p_{\rm lab} - 3.29)$ GeV/c (see the main text).

are taken from Lawrence Radiation Laboratory (Berkeley) data [13]. The dash-dotted curves show the π-exchange contribution which was obtained using only above mentioned u-channel term for the $\pi N \to a_0 N$ elementary amplitude. The result depends on the cutoff Λ_N for a virtual nucleon (we considered $\Lambda_N = 1.2 \div 1.3$ GeV/c). The best description of LBL data can be reached at $\Lambda_N = 1.3$ GeV/c. Note that the πNN formfactor is chosen to be of monopole type with the cutoff parameter $\Lambda_\pi = 1.3$ GeV/c. The dashed curve shows that the $f_1(1285)$-exchange model for $\pi N \to a_0 N$ amplitude leads to drastic underestimation of the data on $pp \to da_0^+$. We took the coupling of $f_1(1285)$ to the nucleon $g_{f_1 NN} = 14.6$ dressed by monopole formfactor with cutoff $\Lambda_{f_1} = 2$ GeV/c (see Ref. [12]). The calculated total cross section of $pp \to da_0^+$ at 2.6 GeV which is maximal energy for COSY is about 100 nb/sr. This value of the cross section makes the corresponding experiment at COSY quite feasible.

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