$f_0(980)$ and $a_0(980)$ Production in the Reaction $dd \to {}^4\text{He}X$ (*

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Direct production of the a_0 resonance in the reaction $dd \to {}^4\text{He}\, a_0^0$ is forbidden if isospin is conserved. It can, however, be observed due to f_0-a_0 mixing

$$\sigma(dd \to {}^4\text{He}\, a_0^0) = |\xi|^2 \cdot \sigma(dd \to {}^4\text{He}\, f_0) \ , \qquad (1)$$

where $|\xi|^2$ is the f_0-a_0 mixing intensity. Therefore it is very interesting to study the reaction $dd \to {}^4\text{He}\,(\pi^0\ \eta)$ at $m^2_{\pi\eta} \sim (980\text{MeV})^2$. Any signal of this reaction will be related to isospin breaking, which is expected to be more pronounced near the f_0 threshold as compared to the region below (or above).

An important point for the feasibility of such measurements is the magnitude of the cross sections $\sigma(dd \to {}^4\text{He}\, a_0^0)$ and $\sigma(dd \to {}^4\text{He}\, f_0)$. Experimental data are not available yet. In Ref. [1] a qualitative estimate of these cross sections was given based on an assumption on the similarity of the cross-section ratios $\sigma(dd \to {}^4\text{He}\, K^+K^-)/\sigma(pd \to {}^3\text{He}\, K^+K^-)$ and $\sigma(dd \to {}^4\text{He}\,\eta)/\sigma(pd \to {}^3\text{He}\,\eta)$. Here we present another estimate by comparing the production of f_0- and ω-mesons in the reactions $dd \to \alpha X$ and $pn \to dX$.

The binary reaction $d_1d_2 \to \alpha X$ proceeds via two-nucleon exchange. We can write the corresponding matrix element as a convolution of two amplitudes, where each amplitude can be described by the one-nucleon exchange. Moreover we consider Reggeized nucleon exchanges. Then we have

$$A^{d_1d_2\to\alpha X}\left(s,\mathbf{q}_\perp\right) = \frac{i}{8\pi^2 s}\int d^2\mathbf{k}_\perp\ T_1\left(s,\mathbf{k}_\perp\right) T_2\left(s,\mathbf{q}_\perp-\mathbf{k}_\perp\right), \qquad (2)$$

with

$$T_j(s,t) = F_j(t)\left(\frac{s}{s_{0j}}\right)^{\alpha_N(t)} \times \exp\left[-i\,\frac{\pi}{2}\left(\alpha_N(t)-\frac{1}{2}\right)\right],$$

where $\sqrt{s}$ is the total c.m. energy and t is the squared 4-momentum transfer. Here we indroduced the two amplitudes $T_1 = T(d_1d_2 \to He^3 n)$, $T_2 = T(He^3 n \to \alpha X)$. It is also useful to define $T_3 = T(pn \to dX)$. All these amplitudes are described by the nucleon Reggeon exchange; $\alpha_N(t)$ is the nucleon Regge trajectory. The residues of the nucleon Regge trajectory for all the reactions considered can be written in the factorized form: $F_1 \sim g_{d_1He^3N_{R1}} g_{d_2nN_{R1}}$, $F_2 \sim g_{He^3\alpha N_{R2}} g_{XnN_{R2}}$, $F_3 \sim g_{XpN_R} g_{dnN_R}$. Due to this factorization the following relations are satisfied

$$\frac{|T(d_1d_2\to\alpha f_0)|^2}{|T(d_1d_2\to\alpha\omega)|^2} = \frac{|T(pn\to df_0)|^2}{|T(pn\to d\omega)|^2} = R(f_0/\omega) = \frac{|g_{f_0nN_R}|^2}{|g_{\omega nN_R}|^2}. \qquad (3)$$

Of course the ratio R might depend on kinematical variables like energy and momentum transfer. To minimize this dependence we take all amplitudes (or corresponding cross sections) at the same c.m. energy release Q.

Recent measurements at ANKE [2] gave $\sigma(pn \to d\omega) = (8.6\pm1.5)\mu$b at $Q = (60\pm18)$ MeV. The cross section for f_0 production in the reaction $pn \to df_0$ was calculated in Ref. [3] as $\sigma(pn \to df_0) = 4 \div 8\ \mu$b at the same Q value (see Fig. 1). Therefore, we have $R = 0.5 \div 1$ at $Q = 40 \div 80$ MeV. The forward differential cross section for the reaction $dd \to \alpha\omega$ has been measured at Saclay [4]: $d\sigma/d\Omega = (1 \pm 0.28)$ nb/sr at 3.32 GeV/c ($Q = 110$ MeV). Assuming angular isotropy we find $\sigma(dd \to \alpha\omega) \simeq (12 \pm 3.5)$ nb at $Q = 110$ MeV. Taking the ratio $R \simeq 1$ at $Q = 110$ MeV we finally get

$$\sigma(dd \to \alpha f_0) \simeq \sigma_0\sqrt{Q/Q_0}, \qquad (4)$$

where $\sigma_0 = (9 \div 15)$ nb and $Q_0 = 110$ MeV. This estimate is by a factor of $3\div5$ larger than one presented in Ref.[1].

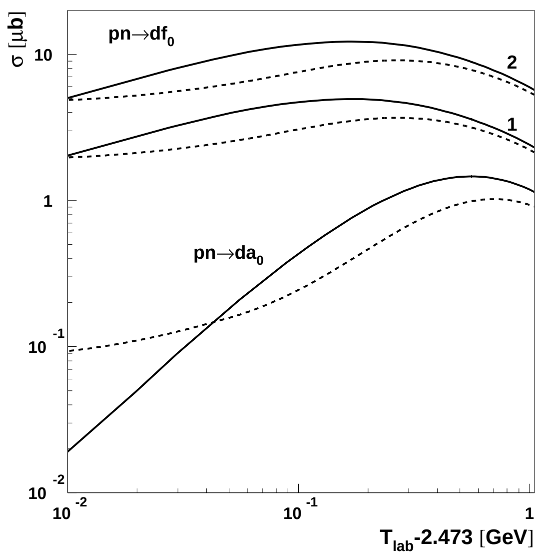

Fig. 1: Total cross sections for the reactions $pn \to da_0$ and $pn \to df_0$. The solid and dashed curves are calculated using narrow and finite resonance widths, respectively. The curves denoted by 1 and 2 correspond to different choices of the f_0NN and a_0NN coupling constants (see [3]).

References:

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