## The cross section of the reaction $pp \to \{pp\}_s\gamma$ in the $\Delta$-isobar region

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Quasi-binary reactions $AB \to \{pp\}_s C$ with formation of a proton pair at small excitation energy $E_{pp} = 0-3$ MeV, i.e. the $^1S_0$ diproton $\{pp\}_s$, are of great interest at high transferred momenta since transition amplitudes of these reactions require high momentum components of the pp-wave function. In comparison to very similar (in kinematics) reactions $AB \to dC$ with the final deuteron $d$, the reactions with the diproton are expected to give more definite information on short-range NN-dynamics. The reason is that the contribution of non-short range mechanisms related to excitation of the $\Delta$-isobars in intermediate states is expected to be strongly suppressed for the $AB \to \{pp\}_s C$ reactions as compared to the $AB \to dC$ due to isospin symmetry and conservation of angular momentum and parity. So, in the reaction $pd \to \{pp\}_s n$ this suppression is given by the factor $\frac{2}{9}$. Furthermore, the intermediate S-wave $\Delta N$ state is completely forbidden in the reaction $pp \to \{pp\}_s \pi^0$. Similarly, in the reaction $pp \to \{pp\}_s\gamma$ direct excitation of the $\Delta-$isobar, dominating the $\gamma d \to pn$ reaction via $M1$ transition is also forbidden [1].

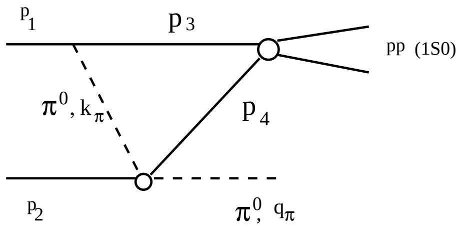


Fig. 1: The one–pion–exchange (OPE) mechanisms considered for

Contrary to those expectations, the reactions $pp \to \{pp\}_s \pi^0$ [2] and $pp \to \{pp\}_s\gamma$ [3] recently measured in forward direction for beam energies $0.5-2.0$ GeV and $0.35-0.55$ GeV, respectively, demonstrate prominent peaks in the $\Delta(1232)$-isobar region. In the deuteron breakup reaction $pd \to \{pp\}_s n$ the $\Delta(1232)$ peak is nonvisible in the energy dependence of the cross section for the backward scattered neutron [4], however, theoretical analyses [5] suggest, that the $\Delta$ contribution dominates in this reaction at $0.5-1.3$ GeV.

Observation of the $\Delta$ peaks in the data on the reactions $pp \to \{pp\}_s\pi^0$ [2] and $pp \to \{pp\}_s\gamma$ [3] would mean that the high momentum component of the NN-wave function, which might be hidden by the $\Delta$- contribution in the corresponding reactions with the deuteron, is actually rather week. In other words, new data [2, 3], most likely, confirm the result of the previous analysis of the reaction $pd \to \{pp\}_s n$ [5], which suggests softness of the NN-interaction potential at short distances. To some extent this conjecture is supported by the one-pion exchange (OPE) model calculation [6], which allows to explain the observed shape of the cross section of the reaction $pp \to \{pp\}_s\pi^0$ by means of the $\Delta(1232)$-isobar excitation in the subprocess $\pi^0 p \to \pi^0 p$ (see Fig.1).

Here we consider the reaction $pp \to \gamma\{pp\}_s$ within the OPE model. The relevant OPE diagram is similar to those in Fig. 1, but with the subprocess $\pi^0 p \to p\gamma$ in the down vertex. Although there is no direct contribution of the intermediate S-wave $\Delta N$ states in the reaction $pp \to \gamma\{pp\}_s$ , the non-direct excitation of the $^5S_2$ $\Delta N$ state is possible in the E2 transition. The OPE model of the reaction $pp \to \{pp\}_s\gamma$ allows to account for the $\Delta$ contributions via the subprocess $\pi^0 p \to p\gamma$. The result of the OPE calculations are shown in Fig.2. One can see that this model explains the observed in Ref. [3] rise of the cross section almost quantitatively. The second bump at 1.6 GeV is caused by the energy dependence of the $\pi^0 p \to p\gamma$ cross section [8] and related to excitation of more heavy nucleon isobars.

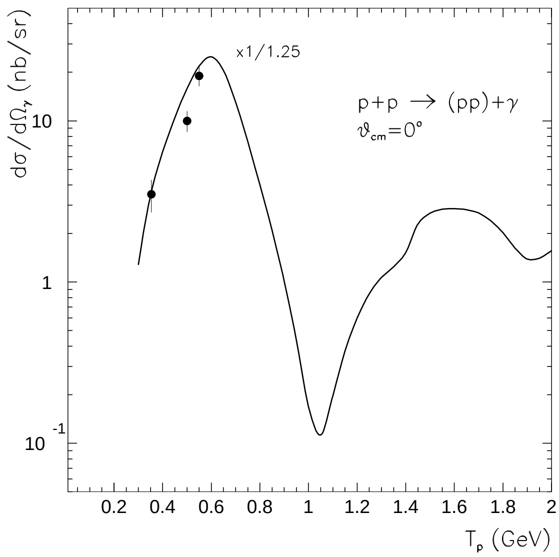


Fig. 2: The forward differential cross section of the reaction $pp \to \{pp\}_s\gamma$ versus the beam energy. The curve (multiplied by 0.8) is the OPE model calculation. Data (•) are taken from Ref. [3].

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