Measurement of the $pn \to pp\pi^0\pi^-$ Reaction in Search of the ABC Resonance*

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Recent data on the basic double-pionic fusion reaction $pn \to d\pi^0\pi^0$ demonstrate that the so-called ABC effect is tightly correlated with a narrow resonance structure in the total cross section of this reaction [1]. The ABC effect denoting a huge low-mass enhancement in the $\pi\pi$ invariant mass spectrum is observed to happen, if the initial nucleons or light nuclei fuse to a bound final nuclear system and if the produced pion pair is isoscalar. Since as of yet no quantitative understanding of this phenomenon has been available, it has been named after the initials of Abashian, Booth and Crowe, who first observed it in the inclusive measurement of the $pd \to {}^3$HeX reaction more than fifty years ago.

In the new exclusive high-statistics measurements of the isoscalar $pn \to d\pi^0\pi^0$ reaction it has been shown that this ABC effect is correlated with a pronounced resonance structure in the total cross section at $\sqrt{s} = 2.37$ GeV with a width of only 70 MeV and quantum numbers $I(J^P) = 0(3^+)$ [1]. This structure is situated about 90 MeV below $\sqrt{s} = 2m_\Delta$, the peak position of the conventional t-channel $\Delta\Delta$ process, and has a width, which is about three times narrower than this process. However, from the Dalitz plots of the $pn \to d\pi^0\pi^0$ reaction it is concluded that this resonance decays nevertheless via the intermediate $\Delta^+\Delta^0$ system into its final $d\pi^0\pi^0$ state.

If this scenario is correct, then also the $pn \to pp\pi^0\pi^-$ reaction should be affected by this resonance, since this channel may proceed also via the intermediate $\Delta^+\Delta^0$ system. We have investigated this question experimentally by using a pd run taken at $T_p = 1.2$ GeV with the WASA detector facility at COSY. The data have been analyzed for the reaction $pd \to pp\pi^0\pi^- + p_{spectator}$ utilizing quasifree kinematics. That way we obtain a data sample spanning the energy region 2.35 GeV $\leq \sqrt{s} \leq$ 2.45 GeV and thus also covering the region of the ABC effect and its associated resonance structure.

The observed differential cross sections are reasonably well described by conventional t-channel resonance processes. In particular the $\pi^0\pi^-$ invariant mass spectra show no ABC effect – in agreement with the fact that the isovector pion pair must be in relative p-wave and hence strongly suppresses any low-mass enhancement. Our data exhibit a smoothly and monotonically rising total cross section in the investigated energy region allowing only an upper limit of about 20 μb for a contribution of the ABC resonance. However, we also see that the conventional t-channel calculations, which were shown to describe the isovector pp-induced channels well, strongly underpredict the observed cross section at lower energies – pointing to a yet unknown isoscalar reaction component.

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