ABC Effect and Resonance Structure in the Double-Pionic Fusion to ^{3}He*

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The ABC effect – an intriguing low-mass enhancement in the $\pi\pi$ invariant mass spectrum – is known from inclusive measurements of two-pion production in nuclear fusion reactions to the few-body systems d, ^{3}He and ^{4}He. It was first observed 1960 by Abashian, Booth and Crowe in the inclusive $pd \rightarrow ^3$He X reaction [1]. Its explanation has been a puzzle since then.

In an effort to solve this long-standing problem by exclusive and kinematically complete high-statistics experiments, we have measured the fusion reactions to d, ^{3}He and ^{4}He with WASA at COSY. Here we report on the measurements of the double-pionic fusion reaction $pd \rightarrow ^3$He $\pi^0\pi^0$. These measurements have been carried out either by a direct measurement at $T_p = 1.0$ GeV as well as by utilizing quasi-free and coherent modes in dd collisons at $T_d = 1.4$ and 1.7 GeV. That way these measurements cover the full energy region, where the ABC effect has been observed previously in inclusive reactions [1, 2].

In a recent kinematically complete measurement of the $pn \rightarrow d\pi^0\pi^0$ reaction we have shown [3] that the ABC effect in this basic double-pionic fusion reaction is correlated with a narrow structure in the total cross section with quantum numbers $I(J^P) = 0(3^+)$, a mass of 2.37 GeV and a width of about 70 MeV. The mass is about 90 Mev below 2 m_Δ, the mass of a $\Delta\Delta$ system and the width is three times narrower than expected from a conventional t-channel $\Delta\Delta$ process.

From a previous exclusive experiment at CELSIUS-WASA at $T_p = 0.893$ GeV [4] it is known, that also the double-pionic fusion to ^{3}He exhibits a pronounced ABC effect. From the new data from COSY we see that this energy is just at about the cross section maximum. Again we observe here a resonance-like structure in the total cross section associated with the ABC effect. This structure peaks at the same excess energy as in the fusions to deuteron and ^{4}He. The width of the structure is in between the widths observed in these two cases.

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