The ABC Effect and its Energy Dependence in the Double-Pionic Fusion to ^{4}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. Its explanation has been a puzzle since 50 years.

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 reactions $dd \rightarrow ^4$He $\pi^0\pi^0$ and $dd \rightarrow ^4$He $\pi^+\pi^-$, which have been carried out at nine beam energy settings in the range T_d = 0.8 - 1.4 GeV. These measurements cover the full energy region, where the ABC effect has been observed previously in inclusive reactions [1].

The Dalitz plots of the data exhibit at all measured energies a huge low-mass enhancement in the $\pi\pi$-invariant mass in agreement with previous measurements [1,2]. However, we do not observe a pronounced high-mass enhancement, which is seen in the inclusive data [1] and which is predicted in conventional calculations [3] based on the $NN \rightarrow d\pi$ subprocess. The Dalitz plots show also evidence that the $\Delta\Delta$ system is excited in the course of the reaction process, though this excitation is below the nominal $\Delta\Delta$ threshold given by 2 m_Δ. These findings are in agreement with the only previous exclusive measurement conducted at T_p = 1.0 GeV at CELSIUS-WASA [2].

Our findings for the double-pionic fusion to ^{4}He are in accordance with the observations for the basic $pn \rightarrow d\pi^0\pi^0$ reaction [4-6] pointing to the same fundamental mechanism. In both reactions we observe a resonance-like energy dependence of the total cross section, tentatively attributed to a "ABC resonance", which apparently is robust enough to survive even in nuclei. In the ^{4}He case the peak structure in the total cross section appears to be broadened in comparison to the deuteron case. This is consistent with collision broadening, which is well understood, *e.g.*, from excitations of the Δ resonance in nuclei.

* supported by BMBF, COSY-FFE(FZ Jülich), DFG (Eur. Graduate School)

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