What is the nature of the ABC Effect?*

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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 the production of an isoscalar pion pair in fusion reactions to light nuclei. 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. These measurements cover the full energy region, where the ABC effect has been observed previously in inclusive reactions. They also complement the systematic measurements of nucleon-nucleon induced two-pion production carried out at CELSIUS-WASA [1-2].

From the data base covering now all pp induced two-pion production channels – including the fusion processes to the deuteron $pp \to d\pi^+\pi^0$ and to quasi-bound ^{2}He – we find that the t-channel Roper, $\Delta\Delta$ and $\Delta(1600)$ excitations are the dominant processes and sufficient for explaining all data for the two-pion production in *isovector* NN collisions.

The situation changes dramatically for the *isoscalar* NN channel. The most basic fusion reaction in this channel $pn \to d\pi^0\pi^0$ exhibits not only a pronounced ABC effect, *i.e.* a low-mass enhancement in the $\pi\pi$ invariant mass spectrum, but in correlation with it also a sharp resonance-like structure in the total cross section. Its peak energy is about 90 MeV below the nominal $\Delta\Delta$ threshold of 2 m_Δ and its width of only 50 MeV is five times less than expected from the conventional t-channel $\Delta\Delta$ process. At the same time the peak cross section is about five times larger than that of the t-channel $\Delta\Delta$ process.

The Dalitz plots of the data exhibit at all energies within this resonance-like structure the ABC effect, *i.e.* the low-mass enhancement in $M_{\pi\pi}$, but simultaneously also the excitation of the $\Delta\Delta$ system, though this excitation is below the nominal $\Delta\Delta$ threshold of 2 m_Δ. At energies above the resonance-like structure the Dalitz plot changes to what is expected from the conventional t-channel $\Delta\Delta$ process.

From the angular distributions we tentatively assign the quantum numbers $I(J^P) = 0(3^+)$ to this resonance-like structure, which is correlated with the ABC effect. At present no conventional process is known, which could at least qualitatively explain this phenomenon. We note, however, that quark-model calculations, notably those of Ref. [3] predict a state with exactly these quantum numbers at about the appropriate mass. However, the estimated width is far too large.

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