Double-Pion Production in Nucleon Collisions on Few-Body Systems - the ABC Effect and its Possible Origin

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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. First exclusive measurements have been carried out at CELSIUS/WASA for the fusion reactions leading to d or ^{3}He. They reveal this effect to be a σ channel phenomenon combined with a resonance-like behavior in the total cross section [1, 2]. The latter points to the formation of an isoscalar dibaryonic resonance, which couples to a $\Delta\Delta$ intermediate state.

In all cases studied so far we observe a huge low-mass enhancement in the σ-channel of the $\pi\pi$ invariant mass distribution. This enhancement at the $\pi\pi$ threshold is much larger than anticipated from previous inclusive measurements and theoretical predictions. Also in contrast to both we do not observe any high-mass enhancements. The πA invariant mass spectra are consistent with a $\Delta\Delta$ system being generated in the intermediate step.

The angular distribution of the $\pi\pi$ system in the center-of-momentum system is consistent with the presence of s- and d-waves. This is in favor of a $J^P = 1^+$ assignment for this s-channel resonance, which then is formed in the $^3D_1$ partial wave of the incident pn system.

Together with the observation that the differential distributions do not change markedly over the resonance region the features fulfil the criteria of a s-channel resonance in pn and $NN\pi\pi$ systems. It obviously is robust enough to survive even in light nuclei (^{3}He, ^{4}He, ...) as a dibaryonic resonance configuration.

From the total cross section of the $pn \to d\pi\pi$ reaction we see that the mass of this resonance is about 70 MeV below the nominal $\Delta\Delta$ mass. Another remarkable feature is that the observed resonance width is smaller than 100 MeV, *i.e.*, less than half of that expected from conventional $\Delta\Delta$ calculations [2]. This might indicate configurations in this resonance, which are less trivial than just pn and $\Delta\Delta$ configurations.

In the $pp \to d\pi^+\pi^0$ reaction, which serves as a control channel, we do not observe an ABC effect – exactly as expected for this isovector case. Simultaneously the energy dependence of the total cross section agrees with that expected from conventional $\Delta\Delta$ calculations.

In order to scrutinize this topic in more detail follow-up experiments have started at WASA-at-COSY by investigating the fusion reactions $pn \to d\pi\pi$ and $dd \to {}^4\mathrm{He}\pi\pi$ over the full energy range of relevance for the ABC effect. The analysis of these data is in progress. First preliminary results will be presented.

[1] M. Bashkanov et al., Phys. Lett. **B637** (2006) 223
[2] H. Clement et al., Prog. Part. Nucl. Phys., in press; arXiv:0712.4125 [nucl-ex]

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