TWO PION PRODUCTION CLOSE TO THRESHOLD IN THE ISOSPIN ZERO CHANNEL*

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The momentum spectrum of ^{4}He particles from d+d reactions at $E_{\rm lab}$ = 570 MeV has been measured at zero degrees in the laboratory. The missing-mass spectrum closely follows a pure phase space behaviour for the isospin zero channel of two pions.

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The search for resonance-like two-pion states has been going on for more than three decades. Still remains to be clarified, both experimentally and theoretically, the origin of the enhancement in the cross section for meson production in the isospin zero channel just above the 2π threshold, the so called ABC effect, named after its discoverers, Abashian, Booth and Crowe [1].

Two pions are produced in an isospin zero state in the reaction $d + d \rightarrow {}^4\mathrm{He} + 2\pi$. The corresponding inclusive reaction was investigated by Banaigs *et al.* [2] for laboratory energies ranging from 0.8 to 2.4 GeV. Their results show that the production of ^{4}He is dominated by the ABC peak, at a missing mass slowly increasing with energy from 300 MeV/c^2 to approximately 350 MeV/c^2 for kinetic energies up to 1.94 GeV. At higher energy the effect starts to disappear. The origin of the very pronounced

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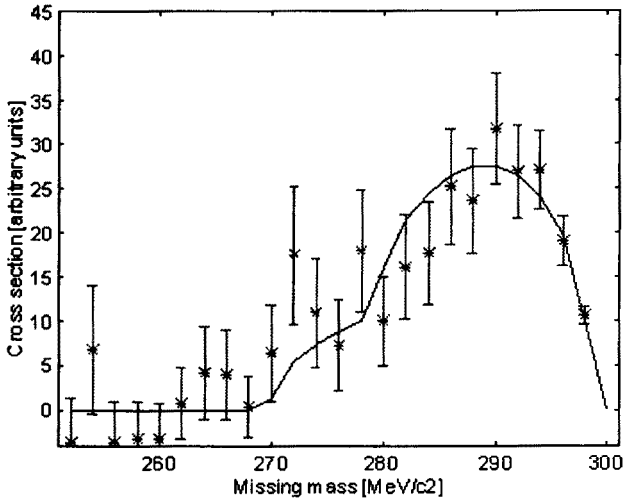
ABC peak is still obscure and in order to further our understanding of the phenomenon additional experimental data are required, in particular in the energy region below 800 MeV.

The CELSIUS synchrotron and storage ring [3] at The Svedberg Laboratory is well suited for meson production studies in the present energy region. However, very close to threshold, where all momenta of the reaction products in the centre of mass system are small, heavy products in particular, leave the reaction very close to zero degrees, i.e. in the immediate vicinity of or even within the circulating beam. In order to detect such heavy reaction products a small size zero-degree spectrometer has been installed in CELSIUS by the Nuclear Physics division at Stockholm University in collaboration with the detector laboratory of the Institut für Kernphysik in Jülich. Particles emitted within 10 mrad of the forward direction are deflected out of the circulating beam by the dipole magnets in the bend following the cluster-jet target and are detected in a set of high-purity germanium detectors.

In the present experiment deuterons were accelerated to a kinetic energy of 570 MeV and alpha particles with a relative rigidity between 0.42 and 0.50 of that of the circulating beam were detected in the Ge-telescope 6.1 m downstream from the target. With a deuterium cluster target, 10^{14} atoms/cm^2 thick, an average luminosity during flat top of $8 \cdot 10^{29}$ cm^{-2}s^{-1} was obtained. Two weeks of measurements resulted in a total integrated luminosity of $2.1 \cdot 10^2$ nb^{-1}.

The missing-mass spectrum in the figure has been obtained from the measured spectrum by correcting for the strongly momentum dependent acceptance of the spectrometer assuming isotropy in the centre of mass system. The resolution is better than 2 MeV/c^2 in the missing mass. The full drawn line corresponds to the two-body invariant phase space for two pions with total isospin zero with a normalization fitted to the experimental result. The threshold forcharged pions can be clearly seen. The experimental spectrum follows the phase space behaviour closely except for a possible peak at an invariant mass of approximately 272 MeV/c^2 with a significance of just over 90%. Assuming isotropy in the centre of mass system our result for the total integrated cross section of the $d + d \rightarrow {}^4\mathrm{He} + 2\pi$ reaction is approximately 45 nb at a laboratory energy of 570 MeV.



As long as the underlying production mechanism conserves isospin any significant deviation from a pure phase space behaviour would ordinarily be expected to show up with twice as large a magnitude for charged pions as for the neutral ones. However, in the present experiment the significant mass splitting may lead to a kinematical suppression of p-wave production of charged pions. The slight excess of events in between the thresholds for neutral and charged pion production therefore may signal a dominant role (not unexpectedly) played by p-wave pion production in the making of the ABC effect.

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