Three-body correlations in the electromagnetic dissociation of ^{6}He

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The dissociation of ^{6}He in a lead target, where the main contribution is expected to come from the electromagnetic dissociation, has been studied at 240 MeV/u. The three-body correlation distributions have been used for the first time in the analysis. The distributions have been directly compared with the results of calculations using the hyperspherical harmonics method while assuming a dipole mode for the electromagnetic dissociation [1]. The experimental data have also been analysed using a series expansion of the final transition amplitude into hyperspherical functions (HH). Each event of the ^{6}He dissociation is characterized by nine parameters: the three components of the momentum vectors for the two neutrons and the α-particle ($\mathbf{p}_1$, $\mathbf{p}_2$, $\mathbf{p}_3$) in the projectile rest frame. We then construct the normalized Jacobi momentum coordinates: $\mathbf{q}_{12} = (\frac{\mu_{12}}{2})^{\frac{1}{2}} \left(\frac{\mathbf{p}_1}{m_1} - \frac{\mathbf{p}_2}{m_2} \right)$; $\mathbf{q}_{3-12} = (\frac{\mu_{3-12}}{2})^{\frac{1}{2}} \left(\frac{\mathbf{p}_3}{m_3} - \frac{\mathbf{p}_1+\mathbf{p}_2}{m_1+m_2} \right)$ where m_i, μ_{12}, μ_{3-12}, $\mathbf{p}_i$, $i = 1, 2, 3$ are masses, reduced masses and momentum vectors of the particle i in the projectile rest frame. Two different Jacobi coordinate system are used: The first coordinate system is labelled $\mathbf{Y}$, where the α core has index 1 and is coupled to the neutron with index 2. The second neutron (3) is then connected with the c.m. of 1 and 2. The second coordinate system is labelled $\mathbf{T}$, where the two neutrons have index 1 and 2 and the α- core (3) is connected to the c.m. of the two neutrons.

- The complete kinematics data as well as the energy and angular corellations in two different coordinate systems have given new insight into the ground-state structure of the Borromean nucleus ^{6}He.
- The comparison with theoretical calculations based on information on gross properties only was shown to be ambigous and it was also shown that information about all three particles in the finals state are essential.
- The experimental continuum energy spectrum and the angular distributions for inelastic scattering of the 240 MeV/u ^{6}He nucleus in a lead target are well described under the assumption of pure electromagnetic dipole dissociation without involving any other reaction mechanisms, while using different theoretical approaches (see Refs. [1, 2, 3]).
- The three-body angular and fractional energy correlations show the importance of both nn and $n\alpha$ final state interactions in the dissociation process. The $n\alpha$ interaction forming the ^{5}He($3/2^-$) resonance is more important than expected from the HH calculations [1]. However, this observation is in line with the results of the complex scaling method [3].

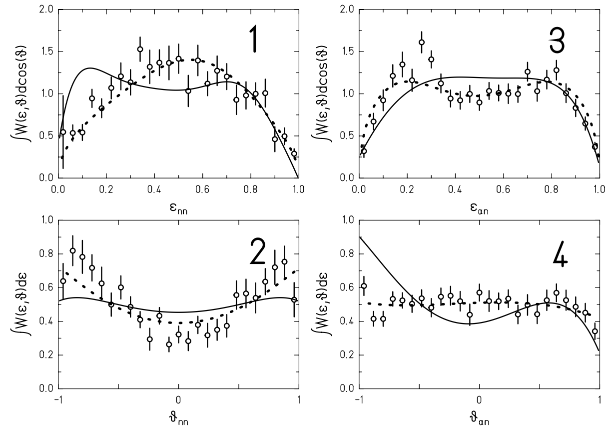

Figure 1: Projections of the probability distribution $\mathcal{W}(\varepsilon, \vartheta)$ in two different Jacobi coordinate systems obtained in the energy region $3-6$ MeV . Figures (1) and (2) are shown in Jacobi configuration $\mathbf{T}$, (3) and (4) in configuration $\mathbf{Y}$. The solid lines show the calculations for dipole Coulomb dissociation [1]. The dotted lines correspond to a fit using a series expansion of the decay amplitude into hyperspherical harmonics.

- The analysis of the experimental data gives evidence for a dominant transition of one neutron from the $0p$-shell to the $1s$-shell. This is in agreement with the calculations [1, 3] at low energies, but in the energy region 3-6 MeV, calculations predict a larger contribution from the $0p$-to-$0d$ transition.
- The analysis of the experimental data gives an indication for the existence of a low energy dipole peak with a possible contribution from the ^{6}He resonant state with a $0p_{3/2}1s_{1/2}$ structure at the continuum energy 3 - 6 MeV.

Thus, the new experimental observables pose new questions to the theoretical models for the dissociation of the Borromean nucleus ^{6}He at high energy and give interesting impact on the development in the theory.

References

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