Breakup of relativistic halo nuclei (i)

P. Adrich[a,h], T. Aumann[a,e], O. Bochkarev[b], M.J.G. Borge[f], L.V. Chulkov[a,b], D. Cortina[a], Th.W. Elze[g], J. Fernandez-Vazquez[a], U. Datta-Pramanik[a], H. Emling[a], H. Fynbo[j], H. Geissel[a], L.V. Grigorenko[a,b], M. Hellström[a], H. Johansson[a,d], A. Klimkiewicz[a,h], K. Jones[a], B. Jonson[d], J.V. Kratz[e], R. Kulessa[h], Le Hong Khiem[a], E. Lubkiewicz[h], K. Markenroth[d], M. Meister[a,d], G. Münzenberg[a], F. Nickel[a], T. Nilsson[i,k], G. Nyman[d], M. Pantea[a,k], R. Palit[a], V. Pribora[b], W. Prokopowic[h], A. Richter[k], K. Riisager[j], C. Scheidenberger[a], G. Schrieder[k], H. Simon[a], K. Sümmerer[a], O. Tengblad[f], I.J. Thomson[c], W. Walus[h], and M.V. Zhukov[d]

[a]GSI Darmstadt; [b]Kurchatov Institute, Moscow; [c]University of Surrey, Guilford; [d]Chalmers Tekniska Högskola, Göteborg; [e]Johannes-Gutenberg-Universität, Mainz; [f]CSIC, Madrid; [g]Johann-Wolfgang-Goethe-Universität, Frankfurt; [h]Universytet Jagiellonski, Krakow; [i]CERN, Geneva; [j]Aarhus Universitet, Aarhus; [k]Technische Universität, Darmstadt

In the studies of the breakup of relativistic halo nuclei, the complete kinematics data as well as the energy and angular correlations have given new insight concerning the ground-state structure of the Borromean nuclei.

For the analysis of experimental data, we propose an effective method based on a series expansion of the transition amplitude into hyperspherical functions. The expansion coefficients are determined from the fit to the experimental distributions. The method makes possible the determination of the relative contribution of different partial waves. The comparison with the theoretical partial amplitudes allows either to choose between different models or to specify changes in the model that would be needed to describe the experimental data.

This was demonstrated with the example of ^{6}He. The dissociation of ^{6}He on a lead target, where the main contribution is expected from the electromagnetic dissociation, has been studied at 240 MeV/u.

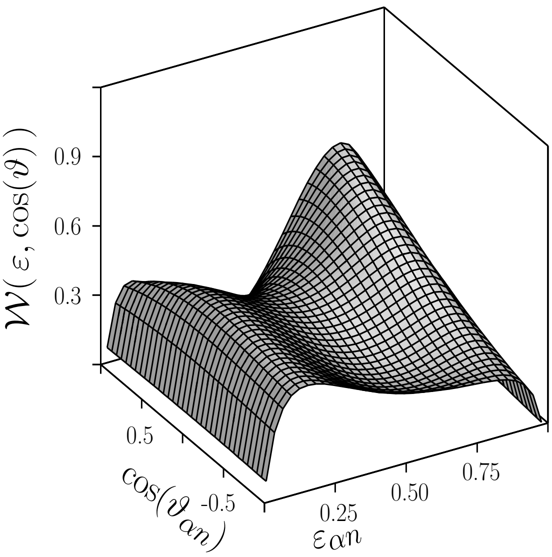

Figure 1: Two-dimensional correlation spectrum reconstructed from the fit to the experimental distributions in the continuum energy region 3-6 MeV.

The experimental continuum energy spectrum and the angular distributions for breakup of the 240 MeV/u ^{6}He nucleus on 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]). The inclusion in the analysis of the three-body correlation distributions results in more strict and quantitative conclusions.

The three-body correlation distributions have, for the first time, been used 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 analyzed by using a series expansion of the final transition amplitude into hyperspherical functions.

Besides the orientation of the whole system, the three-body configuration is determined by the angle $\vartheta_{\alpha n}$ between Jacobi momenta $\mathbf{q}_{\alpha n}$ and $\mathbf{q}_{n-\alpha n}$, by the total energy of the three-body system E, and by the energy shared in a selected pair of particles, e.g. fractional energy in the subsystem α-n, $\varepsilon_{\alpha n} = q^2_{\alpha n}/E$. The dependence of $\vartheta_{\alpha n}$ on $\varepsilon_{\alpha n}$ reconstructed from experimental data in the region $3 < E < 6$ is shown in Fig. 1. Two distinct ridges of the distribution in Fig. 1 correspond to the αn interaction forming the ^{5}He($3/2^-$) resonance. The role of this resonance is more important than expected from the hyperspherical harmonics method [1], but is in line with the results of the calculations made in the framework of the complex scaling method [2]. The analysis has shown that the transition of one neutron from the p-shell to the s-shell dominates. This statement is consistent with the calculations [1, 2] at low energies, but in the energy region 3-6 MeV, theoretical considerations predict a larger contribution from the p- to d-shell transition. The analysis points out the existence of a ^{6}He resonant state with a $p_{3/2}s_{1/2}$ structure at 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 insight in the development of the theory.

References

[1] B.V. Danilin *et al.*, Nucl. Phys. **A 632** (1998) 383

[2] T. Myo *et al.*, Phys. Rev.**C63** (2001) 054313