Breakup of relativistic halo nuclei (ii)

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The quasi-free scattering (QFS) is the dominant reaction mechanism in the nuclear beakup at several hundred MeV/nucleon and provide quite precise information concerning clustering effects in nuclei. In QFS, a probe particle scatters off a bound cluster inside a nucleus. The process leads to a separation of the cluster from the nucleus, the rest of the nucleus acts as a spectator. The transition amplitude may be separated into a reaction term and a nuclear structure term, this property is a prerequisite for nuclear-structure investigations. In the past, QFS studies have provided a wealth of nuclear structure information for stable nuclei. The application of this method to experiments with radioactive beams is very promising. The QFS method has been used in investigations of the cluster structure of drip-line nuclei Refs. [1, 2]. However, these experiments were restricted mainly to the valence-neutron knockout by a complex particle (^{9}Be or ^{12}C). Here we describe a complete-kinematics experiment with a proton as a probe particle and present preliminary results. The experiment was performed at GSI, Darmstadt, where radioactive beams were produced by fragmentation of ^{18}O (308 MeV/nucleon and 362 MeV/nucleon) beams from the heavy-ion synchrotron, SIS, on a beryllium production target. The secondary ^{8}He, ^{11}Li and ^{14}Be beams with energies of 230 MeV/nucleon, 265 MeV/nucleon and 290 MeV/nucleon, respectively, were selected by magnetic analysis in the fragment separator, FRS, and directed towards the liquid-hydrogen target which was placed in front of the large-gap magnetic dipole spectrometer, ALADIN. The experimental setup is shown in Fig. 1. A detection of the recoil proton allows the separation of different QFS channels [3], while a registration of neutrons in coincidence with fragments makes possible the usage of an invariant-mass method.

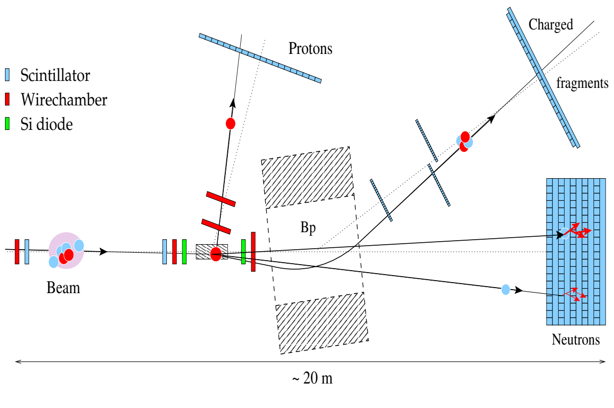

Figure 1: Experimental setup.

Table 1: Preliminary cross sections (mb) for different reaction channels.

Channel	^{8}He	^{11}Li	^{14}Be
$-2n$	20.6 ^{6}He	42.4 ^{9}Li	56.4 ^{12}Be
$-3n$	-	28.5 ^{8}Li	24.1 ^{11}Be
$-4n$	6.5 ^{4}He	15.6 ^{7}Li	-
$-p2n$	-	4.9 ^{8}He	5.9 ^{11}Li
$-p3n$	-	-	-
$-p4n$	0.5 ^{3}H	10.4 ^{6}He	8.7 ^{9}Li
$-p5n$	-	-	7.8 ^{8}Li
$-p6n$	-	9.2 ^{4}He	7.1 ^{7}Li

Estimated cross sections for the breakup of ^{8}He, ^{11}Li and ^{14}Be resulting in different fragments in the final state are shown in Table 1. The neutron knockout has largest cross section. Note, that for Borromean nuclei this channel leads to neutron unstable states. Large cross section is observed for channels which might be associated with the proton knockout. Proton knockout channels will lead to the nuclear-unstable resonances ^{7}H, ^{10}He and ^{12,13}Li. The α-particle knockout from ^{8}He is of special interest in connection with recently renewed discussions of a bound tetra-neutron nucleus [4]. Besides, the spectroscopic factors for neutrons, protons α clusters, and momentum distributions of knocked-out particles and of the spectators are among the main goals of the present experiment.

References

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