Low-energy dipole response of the halo nuclei ^{6,8}He

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The electromagnetic properties of neutron-rich nuclei provide insight into their structure and dynamics.[1)] The low-lying dipole strength of neutron-halo systems is of particular interest. The heaviest bound helium isotopes ^{6}He and ^{8}He are two- and four-neutron halo nuclei with a clear α plus $2n$ and $4n$ structure, respectively. After electromagnetic excitation, they mainly decay *via* two- and four-neutron emission. The ^{6}He breakup has been measured previously by Aumann *et al.*,[2)] while *ab initio* calculations have been carried out by Bacca *et al.*[3,4)] The existing data cover excitation energies up to 7 MeV, while the full low-energy response predicted by the theory extends up to 20 MeV.[4)] Therefore, it is necessary to measure up to higher energies to study the complete region of interest. For ^{8}He, only the $2n$-breakup channel has been measured previously by Meister *et al.*[5)] Nothing is known so far about the $4n$-channel, where ^{8}He breaks up into ^{4}He and four neutrons, because of the experimental difficulties of measuring four neutrons in coincidence.

In July 2017, the SAMURAI37 experiment was performed with the purpose of extending the existing data for ^{6}He with better statistics and measuring the breakup of ^{8}He, both up to excitation energies of approximately 15 MeV. The multi-neutron decay of ^{6}He and ^{8}He after heavy-ion-induced electromagnetic excitation has been measured in complete kinematics to study the dipole response of these nuclei. The combination of the neutron detectors NEBULA and R^{3}B-NeuLAND demonstrator at the SAMURAI[6)] setup and the high beam intensities available at RIBF made the measurement of the $4n$-breakup channel possible for the first time. A primary ^{18}O beam with an energy of 220 MeV/nucleon was used to produce secondary beams of ^{6}He and ^{8}He with an energy of 180 MeV/nucleon and a beam rate of 100 kHz, which were then guided to the SAMURAI spectrometer.

The experimental method is based on the measurement of the differential cross section $\mathrm{d}\sigma(E1)/\mathrm{d}E$ *via* the invariant-mass method, which allows us to extract the dipole-strength distribution $\mathrm{d}B(E1)/\mathrm{d}E$ and the photo-absorption cross section. To excite ^{6}He and ^{8}He electromagnetically, a Pb target was used. Additionally, a series of targets with increasing Z, namely CH_2, C, Ti and Sn, was used to study precisely the nuclear contribution to the cross section. This is especially important in the region of high excitation energy, where the electromagnetic excitation might not be dominant.

The data analysis is in progress.

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References

1) T. Aumann, T. Nakamura, Phys. Scr. **T152**, 014012 (2013).
2) T. Aumann *et al.*, Phys. Rev. C **59**, 1252 (1999).
3) S. Bacca *et al.*, Phys. Rev. Lett. **89**, 052502 (2002).
4) S. Bacca *et al.*, Phys. Rev. C **69**, 057001 (2004).
5) M. Meister *et al.*, Nucl. Phys. A **700**, 3 (2002).
6) T. Kobayashi *et al.*, Nucl. Instr. Meth. Phys. Res. Sect. B **317**, 294 (2013).