Teeter on the brink of nuclear stability

– Experimental investigations of very neutron rich light nuclear systems

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Abstract

Over the past decade, numerous experiments and theoretical investigations have been devoted to dripline nuclei of the lightest elements. Among these, the heavy helium isotopes, belonging to the group where nuclear halo structure was first observed, and the very neutron rich hydrogen isotopes believed to embody a similar structure, attracted much attention. This thesis concerns experimental studies of nuclei having excess neutrons, teetering on the brink of nuclear stability. More precisely, ^{8}He and its unbound subsystem ^{7}He and the two unbound hydrogen isotopes ^{4}H and ^{5}H are studied.

In a complete kinematics experiment performed at GSI, dissociation of 227 MeV/u ^{8}He in carbon and lead targets has been studied. From the data, the relative energy spectra and angular distributions, in the one-neutron knock-out channel ^{6}He+n, and in the diffractive dissociation and inelastic scattering channel into ^{6}He+2n, could be extracted. The data are compared with previously published results of ^{6}He and the unbound ^{5}He to illuminate the resemblances and differences of the corresponding nuclei, revealing a more complicated structure of the two heavier isotopes. In addition, the unbound hydrogen isotopes ^{4,5}H originating from the one-proton knock-out channel of 240 MeV/u ^{6}He in a carbon target have been studied. Relative energy spectra as well as energy and angular correlations in the t+n and t+n+n systems were investigated. The t+n+n relative energy spectrum is observed as a broad structure, peaked at 3 MeV above the threshold, and the two-body t+n system reveals a resonance compatible with earlier results for ^{4}H. In addition, analyzing the energy and angular correlations using the method of hyperspherical harmonic expansion allowed to determine the relative weights of the most relevant partial waves in the three-body t+n+n final state.

Keywords: ^{4}H, ^{5}H, ^{7}He, ^{8}He, angular distributions, breakup reactions, electromagnetic dissociation, exotic nuclei, relative energy spectra, energy and angular correlations, hyperspherical harmonics