From Halo Effective Field Theory to the study of direct reactions: reliably probing the halo structure of ^{11}Be and ^{15}C

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In this work we study one-neutron halo nuclei. These exotic nuclei are found close to the neutron drip-line and exhibit a much larger matter radius than their isobars. This peculiar property is qualitatively understood as due to their low binding energy of one neutron, which then can tunnel far into the classically forbidden region and hence form like a diffuse halo around a compact core. Examples of these systems are ^{11}Be and ^{15}C, which can thus be seen as an inert core of ^{10}Be or ^{14}C plus a neutron. Due to their weakly-bound nature these systems are particularly unstable and hence their structure is studied mostly through indirect techniques, such as nuclear reactions. During the last decades several direct reactions involving these systems have been measured on different targets and different energies [1-8]. Our purpose is to study all these processes using one single structure model for each nucleus.
So, we first find a description of the structure of ^{11}Be and ^{15}C within the Halo Effective Field Theory (Halo EFT) [9], extracting the main parameters to fit the core-neutron interaction from transfer reactions [1-3,10,11]; interestingly we find a good agreement with *ab initio* results for these nuclei [12,13]. Then, we study the breakup of these nuclei at intermediate (about 70A MeV) and high (at 520A and 605A MeV) energy using an eikonal model with a consistent treatment of nuclear and Coulomb interactions at all orders, which takes into account proper relativistic corrections [14]. We compare our results with measurements from RIKEN and GSI [4-7]. Finally, describe the ^{15}C radiative capture and test our results against the measurement of Reifarth et al. [8].
We find that our theoretical predictions are in good agreement with data for each reaction, thus assessing the robustness of the structure model provided for these nuclei. In particular, the use of Halo EFT allows to understand which elements of their structure matter in the description of nuclear reactions. We also show the importance of the inclusion of relativistic corrections in the case of the breakup at high energy.

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