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Search for proton-skin evidence

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Summary

The nuclear mesoscopic system is based on the subtle interplay between single and collective degrees of freedom which manifest themselves depending on the nuclear configuration and excitation. In recent years many efforts have been devoted to investigate evidences for this manifestation and to clarify when one description holds at the expense of the other, when the two coexist and finally when the other takes over.
One of the still disputed phenomenon is the single-particle/collective origin of strength accumulated at the low energy tail of the giant-resonance coherent excitation, commonly referred to as a pygmy resonance.
Experimental observations started in the 50's and 60's, yet only recently NRF focused on the photo-response of nuclei in the region of the particle threshold. The field received a boost with the advent of high-energy radioactive beams and the possibility to study their properties in reaction experiments, see [1] and references therein. Started from 11 Li the predicted and observed large E1 transition probabilities for halo nuclei at the threshold has triggered the idea that a dipole vibrational mode of loosely bound neutrons against a core nucleus should appear and might be observable in neutron-rich nuclei. The gross feature of the E1 response, which is mainly given by the IVGDR, is reproduced quite consistently in many models, the fine structure and especially the energetically low-lying part of the E1 strength often differs more drastically between different calculations, since it is much more dependent on the details of the nuclear forces and theoretical models.
An extensive work has been recently deployed to describe the low-energy electric dipole strength. Various approaches are being used, from HartreeFockBogoliubov plus (quasi-particle) random- phase approximations (Q)RPA based on different interactions [2] to the algebraic Interacting Boson Model [3]. Many of these models predict the E1 strength located at low excitation energies as a signature of the neutron-skin oscillation. While the low-lying component of the E1 strength is observed in almost all calculations, the degree of collectivity is under debate.
In parallel with the neutron skin phenomenon, expected to take place mostly in the neutron-rich nuclei, a proton skin might exist. Calculations have predicted the existence of such evidence in neutron deficient nuclei [4], which are nowadays within reach at the frontier nuclear physics facilities with an adequate intensity.
This LoI aims at investigation of the pygmy strength in neutron-deficient isotopes to establish the degree of collectivity and the possible evidence of a proton skin.
To this end, we plan to populate 42Ti and the completely unknown 44Cr by fragmenting a 78Kr beam, at an energy of 345 MeV/u, onto a thick Be target. The predicted intensity of the 78Kr beam is about 50 pnA. A LISE++ simulation with a 1 g/cm 9 Be target gives a transmission efficiency of about 50% up to the secondary target. In the case of 42Ti more than 10E3 pps are expected at the secondary target, assuming a cross section of about 1 μb. The fragmentation cross section used for the 44Cr yield estimate is 1.1 nb, from EPAX 3.1. The resulting 44 Cr intensity at the position of the secondary target is therefore 12 pps. The use of the DALI2 gamma-ray array is also envisaged to detect the decay out of the pygmy, populated at about 10MeV via a Coulex on a 197Au secondary target.

References

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