Nuclear Halo Studies with 20-GeV Protons

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The nuclear structure of ^{6}Li has been studied with the Boson Dynamic Correlation Model[1]. The BDCM not only reproduces observed energy levels of many nuclei but also gives a dynamical explanation of nuclear halo formation. The model further predicts that ^{6}Li is a long-tailed nucleus like ^{6}He. The r.m.s. radius of the predicted matter distribution is found in good agreement with those extracted from recent p-^{6}Li elastic scattering experiments performed in inverse kinematics at 0.7 GeV/u [2,3]. Because elastic diffraction peak can only provide information about the r.m.s. radius, we propose to study the finer aspect of the predicted matter distribution by using protons having energies of tens of GeV. The use of such high-energy protons has several advantages. We mention, among others, that (a) the large momentum transfers needed to reveal the details of the nuclear structure correspond to very small scattering angles ($\theta < 4^o$), for which eikonal model and Glauber model can be employed with confidence, and (b) in this large-momentum transfer region the Coulomb amplitude is negligibly small, hence, the nuclear structure effect are not masked by the Coulomb interaction. We present our results obtained with protons of 20 GeV, an energy that is readily available at several facilities, such as Brookhaven National Laboratory and the new GSI project.
We compare the p-^{6}Li elastic differential cross sections given by two matter-density distributions which have very similar r.m.s. radii but different nuclear tails. One of them has the halo structure predicted by the BDCM while the other does not have halo. As one will see, both distributions give cross sections that are very close to each other at momentum transfers $q < 0.3$ GeV/c. However, the first diffraction minimum due to the presence of halo occurs at $q \simeq 0.38$ GeV/c while that of the non-halo distribution is at $q \simeq 0.47$ GeV/c, implying a substantial difference in their spatial extensions. Furthermore, the differential cross sections at the second maximum differ by two orders of magnitude. We have thus demonstrated, through the example of ^{6}Li, that high-energy protons represent an ideal tool for probing nuclear halo structure and constitutes a stringent test for nuclear models in the sense that a good model must be able to reproduce simultaneously the experimental energy levels and scattering data up to very large momentum transfers.

References

[1] M. Tomaselli, L.C. Liu, S. Fritzsche, T. Kühl, S.R. Neumaier, W. Nörtershäuser, and I. Tanihata, "Dressed Bosons and Matter Distributions", preprint of GSI, Darmstadt, Germany, and many references included therein. [2] P. Egelhof *et al.* Prog. Part. and Nucl. Phys. $< 49 >$ (2001) 307. [3] A.V. Dobrowolsky *et al.* Proc.Conf.Nucl.Phys. at Border Lines (NPBL), Lipari 2001.