Radius of ^{8}B halo from the asymptotic normalization coefficient

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The proton drip line nucleus ^{8}B has a very small one-proton separation energy (S_p=137 keV) and the valence proton wave function is expected to penetrate substantially beyond the range of the nuclear force. Many experiments have been devoted to studies of ^{8}B in order to establish its halo nature. Interaction and reaction cross section measurements are particularly important since these observables can be directly related to the nuclear size, but they are usually inclusive and not so sensitive to the distribution of the last proton alone. The parallel momentum distribution for core-like fragments in breakup reactions is also easily related to size since it is a direct mapping of the Fourier transform of the halo wave function. Here we have shown that using the experimental asymptotic normalization coefficient determined from peripheral transfer reactions one can obtain the root mean square radius of the wave function for the loosely bound proton in ^{8}B. We have shown that the asymptotic region contributes most and that matching of the interior wave function with the asymptotic part yields a nearly model-independent radius.

The asymptotic normalization coefficient (ANC) for $^8B \rightarrow {}^7Be + p$, specifying the amplitude of the tail of the ^{8}B wave function projected on the two body channel $^7Be + p$, has been determined using the peripheral proton transfer reactions ^{10}B(^{7}Be,^{8}B)^{9}Be and ^{14}N(^{7}Be,^{8}B)^{13}C [1]. An analysis of uncertainties in these two reactions yielded a weighted average ANC $C^2_{p3/2}$=0.388±0.039 fm^{-1}. The rms radius of the last proton is written using the overlap radial integrals from parts of the ^{8}B ground-state wave function where the proton orbits the ground and excited states of the ^{7}Be core, with the first term dominating. Furthermore, one can separate the contributions of the interior and of the asymptotic region, with the latter being calculable in terms of the ANC (determined experimentally) and of a known Whittaker function. Using overlap integrals that differ in the interior of the nucleus, but have the correct asymptotic behavior, we obtain values for the rms radius that differ very little compared with the uncertainty induced by the experimental error of the ANC itself. We used overlap integrals derived from single-particle wave functions calculated in Woods-Saxon, Morse, Gaussian and square well potentials and showed that this conclusion does not depend on the parameters of the potentials. Therefore this method gives us a straightforward, model independent evaluation of the radius of the halo. Our overlap integrals also describe successfully the experimental parallel momentum distributions observed in breakup reactions.

We obtained $\langle r^2 \rangle^{1/2}$=4.20±0.22 fm for the root mean square radius of the last proton, much larger than the rms radius of the ^{7}Be core, r_c=2.33 fm. This large value and the fact that the asymptotic part of the proton wave function contributes 85% to the rms radius are good signatures that ^{8}B is a halo nucleus.

References

[1] A. Azhari *et al*., Phys. Rev. Lett. **82**, 3960 (1999); *ibidem* Phys. Rev. C **60**, 055803 (1999).