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“Laser Spectroscopy in Nuclear Science: The Charge Radius of  $^{11}\text{Li}$ ”

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It was discovered twenty years ago that the matter radius of  $^{11}\text{Li}$ , with three protons and eight neutrons, was as large as that of stable  $^{208}\text{Pb}$  [1]. This unusual property is attributed to very weak binding of the outer two neutrons, such that they form a dilute cloud around the central core, and is known as a neutron “halo” [2]. Many measurements have been made in an effort to understand the halo structure including the momentum distribution, quadrupole moment measurements, and charge-changing cross section measurements.

One of the most prominent questions is whether the halo nucleons influence the core. In the case of  $^{11}\text{Li}$ , it is important to understand whether the  $^9\text{Li}$  core in the  $^{11}\text{Li}$  halo nucleus is different from the “free”  $^9\text{Li}$  core. The charge radius of a nucleus measures its proton distribution, and provides information on the influence of the halo on the nuclear core. The usual method of measuring the charge radius, electron scattering, cannot be applied to  $^{11}\text{Li}$  because the abundance is too low and half-life too short (8 ms).

Recently, a measurement of the charge radius of  $^{11}\text{Li}$  was made by the method of isotope shift in atomic transitions [3]. The technique measures the change in hyperfine transition frequency between two isotopes, and in the current experiment the  $2s \rightarrow 3s$  atomic transition was used for all of the Li isotopes. The experiment was performed at TRIUMF lab, where the production rate of  $^{11}\text{Li}$  was 35,000 ions/s. The first model-independent value for the charge radius of  $^{11}\text{Li}$  was obtained, and can be compared to nuclear models that have been proposed for the effective forces holding this halo structure together.

In this presentation, I will describe the halo structure of  $^{11}\text{Li}$ , and the previous measurements performed in attempt to understand the structure. The recent measurement of the charge radius by method of isotope shift will be discussed in detail, including both theoretical and experimental considerations. The results of this measurement will be compared to current nuclear models in effort to understand the fragile halo structure of  $^{11}\text{Li}$ .

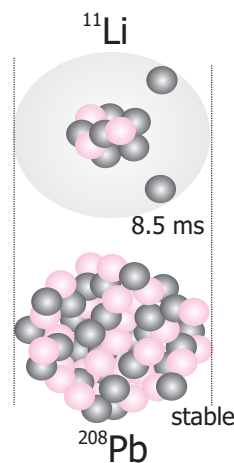


Figure 1. The matter radius of the “halo” nucleus  $^{11}\text{Li}$  compared to that of  $^{208}\text{Pb}$ . Protons are represented by the light spheres and neutrons by the dark spheres.

References:

1. Tanihata, I. *et al.*, Phys. Rev. Lett., 55, 2676 (1985).
2. Hansen, P.G. *et al.*, Europhys. Lett., 4, 409 (1987).
3. Sánchez, R. *et al.*, Phys. Rev. Lett., 96, 033002 (2006)