Nuclear Charge Radius of the Halo Nucleus Lithium-11

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About twenty years ago it was discovered that ^{11}Li has a neutron halo structure – a diluted two-neutron component surrounding a ^{9}Li-like core [1]. Halo nuclei have been the object of many experiments since and our knowledge of this type of exotic matter was steadily improved. However, their charge radii could not be measured in a model-independent way until recently. Progress in atomic theory combined with novel laser spectroscopic techniques allowed now the first charge radius determination of very light, radioactive isotopes by measuring the isotope shift in an electronic transition [2, 3]. Most of the isotope shift observed in the experiment is due to difference in the nuclear mass. QED and relativistic effects are also present and only a 10^{-5} contribution arises from the change in proton distribution inside the nucleus. Atomic structure calculations are able to provide the mass dependent part of the isotope shift with an accuracy of 2×10^{-6} [4]. This is sufficient to extract charge radii with an accuracy at the 2 % level. We report on the first charge radius measurement of ^{11}Li, that has been performed at the TRIUMF-ISAC facility [5]. There, about 30 000 ^{11}Li^{+}/s were produced by a 40 μA, 500 MeV proton beam impinging on a tantalum target. Once the mass separated ion beam was stopped and neutralized, the ^{11}Li Doppler-free $2s\ ^2S_{1/2} \rightarrow 3s\ ^2S_{1/2}$ two-photon transitions were measured and used to calculate the ^{7}Li-^{11}Li isotope shift. The charge radius accuracy for all other lithium isotopes was also improved and the results were compared with theory. The charge radius of ^{11}Li is found to be 2.467(37) fm – which is clearly larger than that of ^{9}Li – while from ^{6}Li to ^{9}Li the charge radii are monotonically decreasing from 2.517(30) fm to 2.217(35) fm.

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