# CHARGE RADIUS MEASUREMENT OF $^6$He IN AN ATOM TRAP


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The measurement of atomic isotope shifts offers unique access to probe the nuclear charge distribution of short-lived isotopes. Here we present a new high-resolution technique based on laser spectroscopy of single atoms in a magneto-optical trap (MOT). The isotopes of interest are $^6$He ($t_{1/2} = 807$ ms) and $^8$He ($t_{1/2} = 119$ ms), which exhibit a loosely bound neutron halo around a $^4$He like core. Charge radii measurements of these isotopes will probe the nucleon interaction and help study the isospin dependence of the three-nucleon force away from stability.

In the case of helium the isotope shifts are dominated by the mass effect, causing shifts of tens of GHz. The contribution of the change in charge radii is only in the order of 1 MHz. Consequently, the isotope shifts have to be measured with an error much smaller than 1 MHz and the atomic structure and nuclear masses have to be accurately known to calculate the mass effect.

Measurements on $^6$He and $^8$He require an on-line experiment with extremely high sensitivity and selectivity. To achieve this a MOT setup has been constructed for trapping helium using the closed $2^3S_1 - 2^3P_2$ transition at 1.083 $\mu$m out of the metastable triplet state. The metastable atoms are populated in a RF driven discharge source and decelerated in a Zeeman slower for efficient trapping. The overall trapping efficiency is on the order of $10^{-9}$ to $10^{-8}$. Single atom detection and isotope shift measurements are performed using the $2^3S_1 - 3^3P_2$ transition at 389 nm.

In a first on-line test of the MOT setup at the ATLAS facility at Argonne single atoms of $^6$He were successfully trapped and detected at a rate of about 15 atoms per 30 Minutes. This number agrees well with the rate expected from the overall trapping efficiency and the $^6$He production rate at ATLAS of about $10^6$/s. Further off-line tests with the stable isotopes $^4$He and $^3$He demonstrated a spectroscopic resolution and accuracy of better than 500 kHz in fine structure and isotope shift measurements with about 100 trapped atoms. Consequently, the trapping rate for $^6$He at ATLAS should allow a charge-radius measurement of this isotope to better than 5% with one day of beam-time in upcoming on-line runs.