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Charge radii of neutron-deficient $^{52,53}\text{Fe}$ produced by projectile fragmentation

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A kink at a nucleon shell closure in mean-square charge radii r_2 along an isotopic chain is a distinct feature of charge radii [1], though the underlying mechanism still remains elusive. Such a feature is clearly visible in the Ca chain at the $N = 28$ neutron shell closure, which has been a major challenge for nuclear theory to understand [2]. In the present study, the r_2 of $^{52,53}\text{Fe}$ below $N = 28$ were determined [3] to investigate how the pattern of r_2 around $N = 28$ changes when moving from semi-magic Ca to Fe isotopes, where the neutron-proton polarization effects are enhanced.

The $^{52,53}\text{Fe}$ beams were produced by fragmentation of a 160-MeV/nucleon ^{58}Ni beam in a Be target at NSCL at MSU. The ^{52}Fe or ^{53}Fe beams were selected using the A1900 fragment separator [4], thermalized in a gas stopper [5], and extracted at an energy of 30 keV. The Fe^+ beam was then transported to the BECOLA facility [6] and bunched-beam collinear laser spectroscopy was performed to measure atomic hyperfine structures (hfs).

Ion beams of the transition-metal Fe are known to be notoriously difficult to produce at ISOL facilities due to long release times from thick targets. The novel scheme of in-flight separation followed by gas stopping was used in the present study for the first time for laser spectroscopy. This is a major step forward and complements such capabilities well established at ISOL facilities, where significant data on r_2 have been obtained for selective elements [1].

The r_2 of $^{52,53}\text{Fe}$ were determined from the isotope shifts of the hfs. The multi-configuration Dirac-Fock method was used to calculate atomic factors. The obtained r_2 of Fe exhibits a sharp kink at $N = 28$, which appears to have a similar structure to the Ca chain. The nuclear density functional theory was used to interpret the results. The underlying mechanisms of the kinks in r_2 of Fe and Ca, as well as the experimental details, will be discussed.

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