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Muonic Atom Spectroscopy of U-238 for the Extraction of Nuclear Properties

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Nuclear charge radii can be determined utilizing muonic atom spectroscopy. Muonic atoms are easily formed by directly stopping negative muons inside a material. Muons are 207 times heavier than electrons and consequently orbit 207 times closer to the nucleus, making them highly sensitive to nuclear properties.

The muX experiment aims to determine the absolute nuclear charge radius of Radium-226 using muonic atom spectroscopy. However radioactive isotopes are usually only available in microscopic quantities. To address this, the muX collaboration developed a novel technique based on transfer reactions in a high-pressure hydrogen/deuterium gas mixture.

Once captured by the target material, the muons cascade down to their ground state, emitting characteristic X-rays. The energies of these X-rays reveal the muonic energy level scheme, which provides insights into properties such as the nuclear charge radius, quadrupole moment, and magnetic moment.

In the case of Uranium-238 (^{238}U), muonic atom spectroscopy was performed to extract its nuclear properties. The muonic ^{238}U spectrum was analyzed, with a focus on studying cascade behaviors associated with both direct and transfer muon capture. Notably, direct muon capture exhibited a preference for transitions from $(n, l = n - 1)$ to $(n - 1, l = n - 2)$ states compared to transfer muon capture, consistent with cascade simulations.

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