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Nuclear Structure with radioactive muonic atoms - The nuclear charge radius of radioactive isotopes by muonic X-rays measurements

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Muonic atoms as laboratories for fundamental physics provide crucial input to QED, the weak and strong interaction.
Muonic atom spectroscopy, i.e. the detection of the muonic X-rays emitted subsequently to the atomic capture of a negative muon, has been a very extensively used technique to determine the extent of the nuclear charge radii [1]. This method complements the knowledge from electron scattering experiments and laser spectroscopy [2].
For elements heavier than Z=83 only few nuclear charge radii have been measured. These measurements are of paramount importance to complement the measurements of relative differences in mean-square radii along the isotopic chain available from laser spectroscopy.
The precision of atomic structure calculation can be limited by the uncertainty on the knowledge of the nuclear charge radius. This is the case for the calculation of effects of atomic parity violation in radium-226 which requires the knowledge of the nuclear charge radius of radium at the level of 0.2% [3].
Till now, experiments with muonic atoms have been limited by low muon rates, poor beam quality and large muon stop volumes, but also by available detector technology. While beam intensities and quality have been improved in recent years, still no high-resolution spectroscopy of muonic cascades and muonic capture has been performed.
The muX project at the Paul Scherrer Institut aims to perform high-resolution muonic atom spectroscopy for the extraction of nuclear charge radii of radioactive isotopes that are available or can be handled only in micrograms quantities. To this end we are employing muon transfer reactions in a high-pressure hydrogen gas cell with a small admixture of deuterium. In 2017 we have shown the validity of this approach by performing a measurement with only 5 ug of gold. The muonic X-rays are detected by a large array of HPGE detectors. Currently we are getting ready for a measurement with radium-226 and curium-248 that will take place this summer. Details on the method developed to perform muonic atom spectroscopy with highly radioactive targets available only in microgram quantities and the first results on the muonic X-ray of radium-226 will be presented.

[0] R.Engfer et al., At. Data Nucl. Data Tables 14, 509 (1974)
[1] G.Fricke and K.Heilig, Nuclear Charge Radii, (Springer-Verlag, Berlin, Heidelberg, 2004)
[2] L.W. Wandenbeck et al. Phys. Rev. C 86, 015503 (2012)

Selected session

Fundamental Symmetries

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