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# Towards Precise Reference Quadrupole Moment Measurements in Transition Metals

The spectroscopic quadrupole moment ($Q$) is a fundamental property that provides information about nuclear deformation. However, its precise extraction for the transition elements remains challenging due to their complex atomic structures. Meanwhile, muonic atoms offer a simpler hydrogen-like structure with amplified hyperfine interaction effects. Recent efforts have revived this technique, successfully measuring the $Q$ of $^{185-187}$Re [1]. Unfortunately, in the mid-$Z$ region, these measurements remain limited by low detection efficiency [2] or poor resolving power [3].
In this talk, I will present a new approach to measuring the reference $Q$ values of transition elements by combining muonic atom spectroscopy with the high efficiency and resolving power of a cryogenic microcalorimeter (MC) detector [4]. I will discuss the associated challenges and feasibility of this measurement based on simulations, using $^{63}$Cu as a test case, along with its detailed theoretical hyperfine interaction calculations using the mcdfgme Dirac-Fock code [5]. Our method aims to overcome the current limitations in precision, reducing the uncertainty in $Q$ by up to a factor of 30. An improved reference quadrupole moment will allow the calibration of entire isotopic chains (including isomers and short-lived excited states), offering a deeper understanding of the nuclear structure.

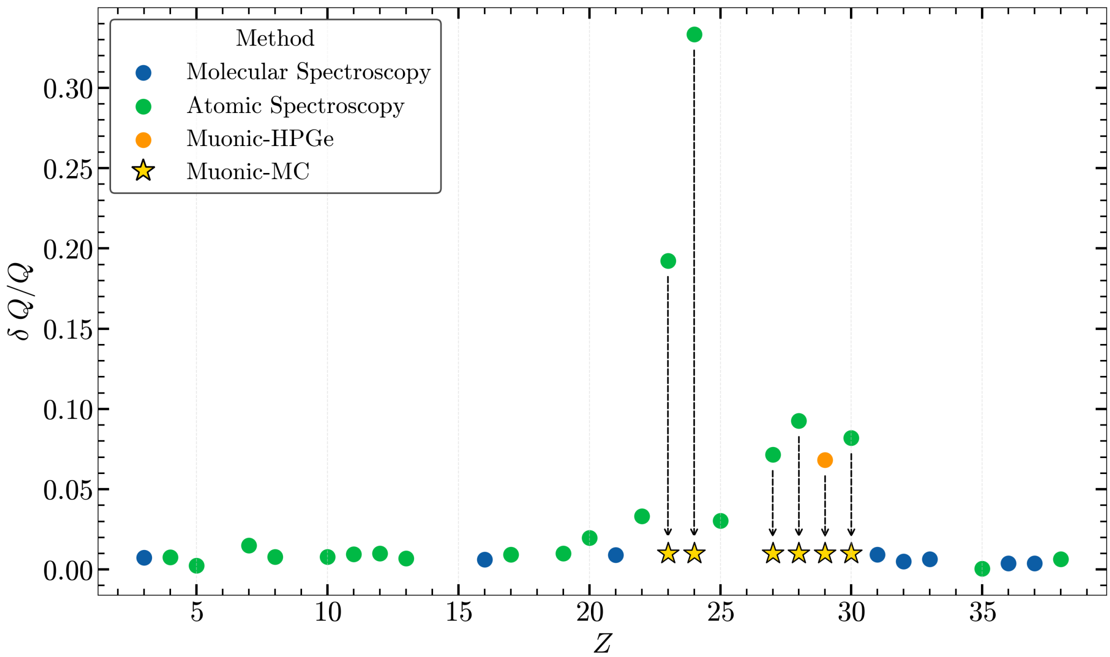


Figure 1: Current fractional accuracy in reference quadrupole moments [6] and our accuracy goals for transition metal nuclei

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