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Doppler-shift lifetime measurements in ^{94}Sr using the TIGRESS integrated plunger

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Neutron-rich Sr isotopes are characterized by a sudden onset of quadrupole deformation at neutron number $N = 60$ demonstrated by the dramatic drop in excitation energy of the first 2_1^+ state. While theoretical calculations reproduce this onset of deformation qualitatively, they differ in the details of the deformation parameters and excitation energies. Though the emphasis is usually put on the sudden onset of collectivity at $N = 60$, it is equally surprising that there is no onset of collectivity when adding up to 8 neutrons beyond the $N = 50$ shell closure, which points to an amazing robustness of both the $Z = 38$ and $Z = 40$ proton (sub)-shell closures. This retardation of the onset of collectivity was first observed by Mach et al. [1] measuring extremely low $B(E2)$ values of ≈ 10 W.u. in even-even Sr isotopes from ^{90}Sr to ^{96}Sr using the fast timing technique. These measurements have an uncertainty of $\approx 40\%$ and are at the limit of the fast timing technique with lifetimes of ≈ 10~ps; a high precision lifetime measurement in ^{94}Sr will elucidate whether the onset of collectivity is as sudden as generally assumed.

Intense re-accelerated beams delivered by the ISAC-II facility at TRIUMF, Canada's national laboratory for particle and nuclear physics, permit access to nuclear structure information for a wide range of radionuclides via in-beam gamma-ray spectroscopy with TIGRESS, a high-efficiency and Compton-suppressed segmented HPGe array. To take advantage of this opportunity, the TIGRESS Integrated Plunger (TIP) has been constructed at Simon Fraser University [2]. The TIP infrastructure supports Doppler-shift lifetime measurements via the Recoil Distance Method (RDM) using a 24-element TIP CsI(Tl) wall for charged-particle identification. An experiment aimed towards a high-precision ($< 10\%$) measurement of the $B(E2, 2_1^+ \rightarrow 0_1^+)$ reduced transition probability in ^{94}Sr was performed in December 2015 using inelastic scattering near the Coulomb barrier coupled with an RDM lifetime measurement of a radioactive ^{94}Sr beam. A Geant4-based code for TIP is being developed as a tool to aid the analysis and for the optimization of future experiments. The device, experimental approach, analysis, and preliminary results will be presented and discussed. This work is presented on behalf of the TIP and TIGRESS collaborations.

[1] Mach et al., Nucl. Phys. A 523 (1991) 197.
[2] P. Voss et al., Nucl. Inst. and Meth. A 746 (2014) 87.

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