Search for Proton Decay from an Isomer of ^{77}Rb with RAMA

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Direct proton emission was first discovered in a high spin isomer of ^{53}Co [1,2]. The measured half-life of ^{53m}Co is 247 ms and this proton decay is a 1.5% branch. Subsequently, ground state proton emission has been observed in many nuclei from ^{105}Sb to ^{187}Re; however, ^{53m}Co remains the only example of proton decay from an isomeric state of a nuclide with a proton-bound ground state. There is a prediction[3] that several nuclides in the mass 80 region could also have high-spin isomers which would be unbound to proton emission.

One such nuclide, ^{77}Rb, is predicted to have an isomer that is unbound by 2.93 MeV. This isomer would have a spin of $19/2^-$ and would be formed by coupling a single $f_{5/2}$ proton hole state with a pair of $g_{9/2}$ neutrons. Although proton decays of this energy typically occur in $<10^{-15}$s, Bugrov *et al.*,[4] have predicted a proton-decay partial half life of 240 ms due to the large centrifugal barrier for this decay (l=9). In order to allow the proton decay to be observed, gamma decay would have to be strongly hindered. Although gamma deexcitation to one of the high-spin rotational-band states known to lie below the isomer in excitation energy could in principle occur, differences in the wavefunctions of these collective-mode states and the many-particle isomeric state may lead to significant gamma-decay suppression.

^{77}Rb is produced in high yield in the ^{40}Ca(^{40}Ca, 3p) reaction at 150 MeV. Unfortunately, competing reactions produce not only the well-known beta-delayed proton emitter ^{77}Sr [5] , but also weak delayed-proton emitters, observed by our group in previous helium-jet studies. This leads to a weak proton background up to 6 MeV . For this reason, we had to employ our on-line mass separator RAMA[6] to eliminate this proton background. Previous studies of alkali metals demonstrated typical efficiencies of 1%. However, the large recoil energies present in this reaction significantly lower the helium-jet efficiency from a typical value of 50% to less than 5%. A recent test measurement demonstrated an efficiency for Rb commensurate with these expectations.

RAMA[7] has been fully upgraded in the past several years. To allow the separator to be fed by a capillary that is only 25 cm long, the ion source has been moved to the bombardment area, just above the target. This change has reduced the He-jet transport time from 200-300 ms to approximately 15 ms. The recently-completed search for the proton decay of ^{77m}Rb represented the first long experiment to utilize RAMA since the upgrade was completed.

Throughout the experiment, the amount of ^{77}Rb activity collected was monitored via observation of the beta-delayed gamma-ray decays of the ground state. Preliminary analysis indicates that approximately $2x10^6$ ^{77}Rb atoms were transported to the detector station during the 5-shift bombardment. To measure proton decays, we employed a single gas ΔE- gas ΔE-silicon E telescope subtending a solid angle of 23 $\pm$1% of 4π. Since there could have been unusual events due to high voltage sparking of the RAMA electrostatic components, we continued running the detectors and RAMA at mass 77 for an additional 6 shifts to adequately check the background rate. No adjustments to the mass separator were necessary during the entire 11 shifts.

Preliminary analysis of the data has yielded no evidence of the predicted proton peaks. Our sensitivity is approximately $1x10^{-5}$ relative to feeding of the ground-state (based on the detector solid angle and the number of atoms transported). This indicates that either the isomeric state is not strongly fed by the reaction used, gamma-decay is insufficiently hindered to allow proton emission to compete or a combination of these two effects is present.

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