Measurement of multiple isobar chains as a first step toward SHE identification via mass spectrometry†

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In the search for the long-predicted "island of stability", the use of so-called hot-fusion reactions has allowed for extending the table of isotopes up to element-118 in recent years. A dearth of projectile-target combinations available for cross-bombardment reactions and α-decay chains terminating in spontaneous fission before reaching well-known nuclei were bottlenecks to acceptance of element-113, -115, -117 and -118[1)]. As we push ever closer to the island of stability, whether by use of more exotic projectile-target combinations or use of multi-nucleon transfer reactions[2)], this problem will become ever more severe; we can expect many spontaneously fissioning nuclei, longer α-decay half-lives, and a recurrence of β-decay[3)].

As the first step toward mass spectrographic identification of SHE, we have installed a gas cell connected to an MRTOF-MS[4)] after the gas-filled recoil ion separator GARIS-II[5)]. We have used this system to initially perform mass measurements with fusion-evaporation reaction products lighter than uranium, the masses of some of which have not previously been directly measured. In these measurements we demonstrate the ability of the MRTOF-MS to simultaneously measure the masses of atomic (and molecular) ions across multiple isobar chains. With reasonable statistics a high-precision can be achieved, while with less than 10 detected ions the mass can be determined with sufficient precision to identify an ion species.

A 1.5 pμA beam of $^{40}Ar^{11+}$ at 4.825 MeV/u was provided by the RIKEN heavy-ion linear accelerator RILAC. The beam impinged upon a rotating target wheel with 16 target windows. The target wheel comprised 4 windows of $^{165}_{67}$Ho with a thickness of ~0.14 mg/cm^2 and 12 windows of $^{169}_{69}$Tm with a thickness of ~0.29 mg/cm^2. The ^{165}Ho and ^{169}Tm targets were prepared using sputtering and electro-deposition methods, respectively, on 3 μm Ti backing foil. A rotating shadow wheel ensured the beam could only impinge on one type of target at a time[6)].

Figure 1 shows the spectrum seen when bombarding the $^{169}_{69}$Tm target. We were able to simultaneously observe the 3n and 4n evaporation channels, ^{205,205}Fr$^+$, in a single time-of-flight spectrum. At the same time we could observe lighter isobars, although whether they were decays or $xpyn$ evaporation channels could not be definitively determined.

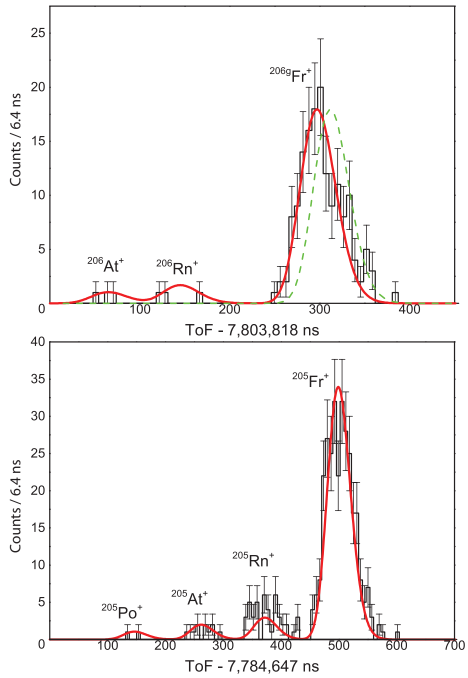

Fig. 1. Spectrum observed for A/q=201, 205, and 206 species at n=148 laps.

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