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Mass Measurements of Neutron-rich Rare-earth Isotopes

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The rapid neutron capture process (r process) is thought to be responsible for the production of roughly half of the heavy elements found in nature, however the site of the r process is unknown and remains one of the most active areas of research in nuclear astrophysics. Testing r-process predictions requires experimental nuclear data inputs including masses, beta-decay properties, and neutron-capture rates. A recent study [1] has posited a link between the formation of the rare-earth peak near N = 100 and an array of potential r-process sites, but there is currently little available nuclear data in this region. As current RIB facilities improve and next-generation facilities come online, the opportunity to test such r-process calculations and inspire others is quickly growing. One such facility is CARIBU, located at Argonne National Laboratory, where intense beams of neutron-rich isotopes are produced from the spontaneous fission of 252Cf. The recent commissioning of a MR-TOF at CARIBU provides highly mass-resolved (R>50,000) beams to the low-energy experimental area where the Canadian Penning Trap mass spectrometer (CPT) is housed. A major upgrade to the detector system at the CPT has been made in order to implement the contemporary Phase-Imaging Ion-Cyclotron-Resonance (PI-ICR) mass measurement technique [2], which has allowed us to probe further from stability than was previously possible. PI-ICR is intrinsically more efficient than other Penning trap mass measurement schemes and offers increased sensitivity to more weakly produced isotopes without loss in precision. Buoyed by the MR-TOF, this new technique has been used to determine the masses of a number of previously unmeasured rare-earth nuclides around A~160 in the past year. The benefits of PI-ICR and the astrophysical implications of the newly measured masses will be discussed.

References:
[1] M. Mumpower et al., ApJ, 833, 282, 2016
[2] S. Eliseev et al., Phys. Rev. Lett. 110, 082501, 2013
[3] T.Y. Hirsh et al., Nucl. Instr. Meth. Phys. Res. B, 376, 229, 2016

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