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Influence of Fission on the Prospects for Discovering the Next New Element

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The four elements that were officially named most recently were all discovered in so-called “warm fusion” reactions, where compound nuclei with excitation energies of ~40 MeV are produced. The key to these experiments has been the use of neutron-rich 48Ca projectiles, which produce nearly spherical compound nuclei when reacting with actinide targets. The relatively neutron-rich compound nuclei have relatively low neutron binding energies and relatively high probabilities of survival against fission. However, more recent experiments to produce new elements using heavier projectiles have not been successful. The cross sections for all of these reactions are extremely small, so recent work at Texas A&M University has studied the reactions of similar projectiles with lanthanide rather than actinide targets. Systematic variation of the projectile and target have allowed for variation of the capture cross section as well as the difference in neutron binging energy and fission barrier height. Excitation functions for the xn and pxn exit channels of a large number of projectile/target combinations have been measured using the MARS spectrometer. A simple theoretical model has been developed that allows for the estimation of the fission and particle emission probabilities from the compound nuclei. It adequately describes the cross sections of 48Ca-induced reactions using only the fission and neutron emission widths, but describing the cross sections of reactions induced by 44Ca and 45Sc projectiles requires the inclusion of the proton and alpha emission widths. Collective effects have been found to be significant, and are needed for accurate description of the cross sections. These results suggest that the discovery of new elements will largely be controlled by the ability of the compound nucleus to survive against fission. This talk will summarize the previous work, the most recent results using 40Ar and 44Ca projectiles, and the theoretical model. Additional remarks will be made on the prospect of using radioactive beams for heavy element synthesis.

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