Measurement of the ^{208}Pb(^{52}Cr, n)^{259}Sg Excitation Function

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Cold fusion reactions, where a weakly excited compound nucleus is formed in the complete fusion of an A ~ 50-70 projectile with ^{208}Pb or ^{209}Bi targets, have been used to successfully produce a number of transactinide elements. Typically, the most neutron-rich projectiles are used to increase the neutron number of the compound nucleus, with an expected increase in the stability of evaporation residues. Unfortunately, systematic studies of this effect using a variety of reaction partners have been lacking, so the goal of the current work was to investigate the impact of projectile neutron number on cross section by measuring the excitation function for the ^{208}Pb(^{52}Cr, n)^{259}Sg reaction. An extension to higher projectile energies also allowed for a partial measurement of the ^{208}Pb(^{52}Cr, 2n)^{258}Sg excitation function. Preliminary results are presented in this report.

Experiments were conducted at the Lawrence Berkeley National Laboratory (LBNL) 88-Inch Cyclotron using the Berkeley Gas-filled Separator. The setup was identical to that described in [1], except that beam shutoff parameters were optimized for ^{258,259}Sg. A portion of this research was conducted in conjunction with the Fourth RIA Sumer School on Exotic Beam Physics, held at LBNL July 31-August 6, 2006. This allowed graduate students attending the summer school to observe an actual heavy element experiment. Due to an additional "hands-on" experiment conducted simultaneously, it was necessary to periodically deliver the beam to a different cave for approximately one hour at a time. The 88-Inch Cyclotron operations staff developed a novel fast (~0.5 h) beam retuning procedure which made this possible within the significant time constraints.

Luminosities were measured by recording Rutherford scattered beam particles using *p-i-n* detectors. Due to deviations from the expected relation between the observed Rutherford pulse heights and the square of the Cyclotron frequency, the energies at the center of the 470-μg/cm^2 ^{208}Pb targets were estimated from the pulse heights subject to the condition that the energy of maximum cross section should be as predicted by the "Optimum Energy Rule" [2]. The accuracy of this rule has recently been demonstrated by our group [1]. Assignment of decay chains was straightforward due to the very different decay properties of ^{259}Sg ([90 ± 10]% alpha, $t_{½}$ = $0.48^{+0.28}_{-0.13}$ s) [3] and ^{258}Sg (100% spontaneous fission, $t_{½}$ = $2.9^{+1.3}_{-0.7}$ ms) [4].

The measured (partial) excitation functions for the production of ^{258,259}Sg are shown in Fig. 1. The ^{208}Pb(^{52}Cr, n)^{259}Sg excitation function appears complete, although the upper limit at 251.6 MeV is anomalous. The very large error bars at 253.1 MeV are due to low statistics and a very low dose of only ~2 × 10^{16} beam particles collected at this energy. In comparison with the excitation function published for the ^{208}Pb(^{54}Cr, n)^{261}Sg reaction (see Fig. 4 in [5]), the maximum cross section has been reduced by a factor of ~10. A similar comparison is possible using the ^{208}Pb(^{48}Ti, n)^{255}Rf [6] and ^{208}Pb(^{50}Ti, n)^{257}Rf [5] reactions. In the case of ^{48}Ti projectiles, the peak cross section was reduced by a factor of ~50 relative to the reaction with ^{50}Ti projectiles. The ^{52}Cr excitation function also does not show the steep slope on the low-energy side that is predicted and observed in the ^{48}Ti reaction. Theoretical investigation will be required to interpret these results.

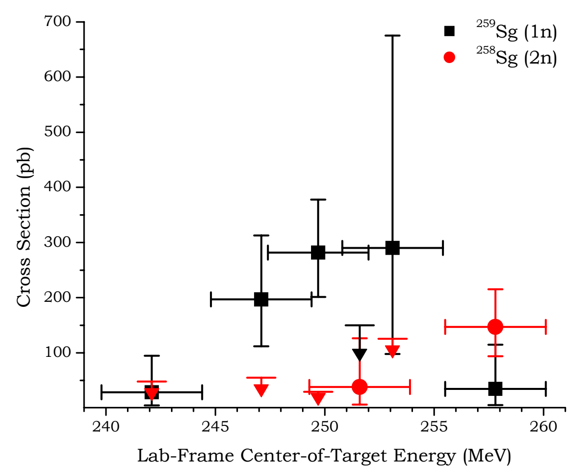

FIG. 1: Measured excitation functions for the reaction of ^{52}Cr with ^{208}Pb to produce ^{259}Sg (black squares) and ^{258}Sg (red circles). Vertical error bars are 68% limits, while upper limits are shown at the 86% confidence level. Horizontal error bars represent projectile energy coverage in the target.

REFERENCES

[1] C. M. Folden III *et al.*, Phys. Rev. C **73**, 014611 (2006).
[2] W. J. Świątecki *et al.*, Phys. Rev. C **71**, 014602 (2005).
[3] G. Münzenberg *et al.*, Z. Phys. A **322**, 227 (1985).
[4] F. P. Heßberger *et al.*, Z. Phys. A **359**, 415 (1997).
[5] S. Hofmann *et al.*, Nucl. Phys. **A734**, 93 (2004).
[6] I. Dragojević *et al.*, this report.