Entrance Channel Effects in the Production of ^{262,261}Bh

S.L. Nelson[1,2], C.M. Folden III[1,2], K.E. Gregorich[1], I. Dragojević[1,2], Ch.E Düllmann[1,2,3], R. Eichler[4,5], M.A. Garcia[1,2], J.M. Gates[1,2], R. Sudowe[1], H. Nitsche[1,2]

[1] Nuclear Science Division, Lawrence Berkeley National Laboratory, Berkeley, California 94720
[2] Department of Chemistry, University of California, Berkeley, California 94720
[3] Gesellschaft für Schwerionenforschung mbH, D-64291 Darmstadt, Germany
[4] Labor für Radio-und Umweltchemie, Paul Scherrer Institut, CH-5232 Villigen PSI, Switzerland
[5] Departement für Chemie und Biochemie, Universität Bern, CH-3012 Bern, Switzerland

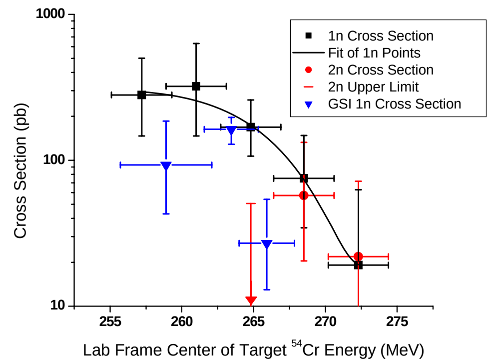
"Cold" nuclear fusion reactions have been used for many years in the synthesis of new transactinide elements. [1,2] The reactions producing odd-Z compound nuclei (CN) have been studied using even-Z projectiles on ^{209}Bi targets (as opposed to odd-Z projectiles on ^{208}Pb targets) because the lower effective fissility [3] was expected to lead to larger cross sections. Many odd-Z projectile reactions producing odd-Z CN have not been studied in-depth. A study of these reaction pairs would be instructive in understanding the role a specific target and projectile combination, or entrance channel, plays in CN formation. Our group has initiated these studies using the Berkeley Gas-Filled Separator (BGS) at the Lawrence Berkeley National Laboratory 88-Inch Cyclotron.

Bohrium was discovered as ^{262}Bh in the ^{54}Cr + ^{209}Bi reaction and that reaction's excitation function was later measured [4]. Recently, Folden *et al.* produced the same CN in the complementary ^{55}Mn + ^{208}Pb reaction [5] in an attempt to measure its excitation function. The observed maximum cross section of this reaction was more than a factor of three greater than the ^{54}Cr + ^{209}Bi reaction, contrary to what would be expected based on an effective fissility argument. Therefore, we have chosen to re-examine the ^{54}Cr + ^{209}Bi work, compare it to the ^{55}Mn + ^{208}Pb by Folden *et al.*, and explore production of the 2*n* product, ^{261}Bh, with each reaction.

The "Optimum Energy Rule" by Swiatecki, Siwek-Wilczynska, and Wilczynski [6] was used to choose the projectile energy at the theoretical maximum of the 1*n* excitation functions, and several additional energies were studied. Five different lab-frame, center-of-target projectile energies of were run for ^{54}Cr, and three in a continuation of [5]. The targets' areal densities were 441 μg/cm² and 470 μg/cm² for ^{209}Bi and ^{208}Pb, respectively. The magnetic rigidity of the observed products was 2.16 T·m. The preliminary measured excitation functions can be seen in Fig. 1.

Our observed decays are in agreement with previously published data on $^{262g,m,\,261}$Bh. 18 1*n* and three 2*n* events were detected in the ^{54}Cr + ^{209}Bi reaction, and three 2*n* events in the ^{55}Mn + ^{208}Pb reaction. One direct spontaneous fission (SF) event was observed, possibly indicating a small SF branch previously not seen in ^{262}Bh.

The excitation function for the 1*n* product of the ^{54}Cr + ^{209}Bi reaction is in agreement with the previous work [4]. However, this result does not give an explanation for the surprisingly large cross sections found in the ^{55}Mn + ^{208}Pb 1*n* work. A preliminary assessment of the 2*n* magnitudes shows no such preference of entrance channel, as they are nearly identical. This result is most likely due to the similar onset of third chance fission. Studies to finish this Bh work by extending the excitation functions and continuing with elements Db (Z=105) and Mt (Z=109) are planned.



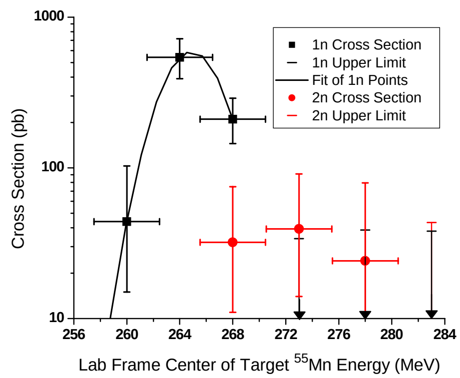


FIG. 1: Preliminary measured excitation functions for the ^{209}Bi(^{54}Cr, x*n*)$^{263-x}$Bh reaction (above) and the ^{208}Pb(^{55}Mn, x*n*)$^{263-x}$Bh reaction (below). The 1*n* results are shown with black squares, and 2*n* results are shown with red circles. Vertical error bars represent the 68% confidence interval (1σ), and horizontal error bars represent energy spread in the target due to energy loss. In all cases $^{262g,\,m}$Bh have been summed.

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