Isotopic yields from deep-inelastic reactions.

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Neutron-rich nuclei are notoriously difficult to produce with fusion reactions due to the low N/Z ratio of the projectile-like and target-like nuclei and neutron evaporation. The deep inelastic reaction mechanism, on the other hand, has the ability to access these nuclei with the additional prospect of generating large amounts of rotational angular momentum [1].

In spite of the considerable knowledge accumulated concerning this mechanism, its arrival to the field of nuclear structure physics is comparatively recent. Although it has been demonstrated that the mechanism is capable of generating high spins in neutron-rich nuclei [2], little is known about the dependence of the cross sections on beam-target combinations or energy.

To study these questions a series of experiments were conducted using the Gammasphere array at the 88-inch cyclotron at Lawrence Berkeley National Laboratory. The three experiments, ^{48}Ca+^{176}Yb at 250 MeV, ^{154}Sm+^{176}Yb at 950 MeV and ^{154}Sm+^{208}Pb at 1 GeV, were purposefully designed to keep a nucleus common between successive experiments. The energy of each projectile was kept near 20% above the Coulomb barrier. Identification of the reaction products was accomplished solely on the basis of γ-ray spectroscopy. Since these γ-rays are emitted by projectile-like and target-like nuclei recoiling at high energies, they are strongly Doppler shifted. The velocity vectors were measured by a multi-segmented silicon strip detector placed in the GAMMASPHERE target chamber roughly an inch behind the target and centered around the beam line. With the aid of two-body kinematics and the direction of the emitted photons supplied by GAMMASPHERE it is possible to correct for these Doppler shifts.

In the first experiment 17 nuclei were populated, including ^{173}Tm, which has seven fewer neutrons than the target nucleus [3]. Population of the reaction products in that experiment is consistent with N/Z and Q-value considerations, which drives the reaction products towards the N/Z ratio of the hypothetical compound nucleus and towards positive energy transfer, respectively. Multiple neutron transfer was also seen in the latter two experiments, although large Doppler shifts negatively impacted the resolution and, thus, observation of weak channels. Figure 1 shows the isotopic yields from these two experiments, which are not so easily accounted for by N/Z and Q-value considerations [4]. Calculations are being made to clarify these results.

		^{152}Sm 0.78	^{153}Sm 0.59	^{154}Sm 10.5
^{172}Yb 0.49		^{174}Yb 1.24	^{175}Yb 0.22	^{176}Yb 66.0

^{152}Sm 1.0	^{153}Sm 1.0	^{154}Sm 16.2	^{155}Sm 0.2	^{156}Sm 0.15
^{206}Pb 2.1	^{207}Pb 3.8	^{208}Pb 6.1	^{209}Pb 0.2	

Figure 1: Isotopic yields (mb/sr) from ^{154}Sm+^{176}Yb (top) and ^{154}Sm+^{208}Pb at 1 GeV.

References

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