HIVAP calculations for the synthesis of new isotopes of Z=116 and Z=118 through ^{250}Cm(^{48}Ca,xn) and $^{250-252}$Cf(^{48}Ca,xn) reactions

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Introduction

The production and study of superheavy elements is an important area of research in contemporary experimental nuclear physics. The heaviest element produced so far is Z=118 (one isotope with A=294) in the ^{48}Ca+^{249}Cf [1] reaction with a production cross-section of 0.5 pico barns. Here we propose ^{250}Cm(^{48}Ca,xn) and $^{250-252}$Cf(^{48}Ca,xn) reactions for the synthesis of heavier isotopes of Z=116 and 118 with comparable theoretical production cross-sections. ^{250}Cm, ^{250}Cf, ^{251}Cf and ^{252}Cf are feasible targets with half lives of 8300, 13.1, 898 and 2.6 years respectively.

Details of the calculation

In this work we present excitation functions for the production cross sections of the isotopes $^{294-296}$118 in the reactions $^{250-252}$Cf(^{48}Ca,xn) . For these calculations we have used the HIVAP code [2] which is based on the conventional two step process of complete fusion and the subsequent statistical de-excitation of the compound nucleus producing the evaporation residue (EVR) of interest. Fusion is assumed to occur beyond the touching point and the fusion barrier is calculated from the global nucleus-nucleus potential of Bass [3]. It uses a dynamically fluctuating barrier assumed to be a Gaussian distribution to account for the coupled channel effects, for the calculation of fusion probabilities. The classical statistical evaporation theory is used for the de-excitations of the compound nucleus. The important level density parameters a_n and a_f for neutron evaporation and fission channels as prescribed by Reisdorf are [2] used. We also use available experimental masses in the calculation. The details of the calculation are given in reference [4].

Results and discussion

The variation of the calculated production cross sections with excitation energy E* of the compound nucleus is shown in Fig.1. Here $E^*=E_{CM}+Q$ with $Q=(M_P+M_T-M_{CN})C^2$ where M_P (M_T) is the ground state mass of the projectile (target) and M_{CN} is the mass of the compound nucleus. Here B_{int} = Bassbarrier + Q.

From Figure 1, as is consistent with the trend for cross-sections using the ^{48}Ca projectile, the calculated cross sections are in the range of pico barns both for the 4n ($E^* \sim 45$ MeV) and 5n ($E^* \sim 51$ MeV) channels, in all the three reactions. Therefore these can be measured with currently available experimental facilities assuming the availability of sufficient quantities of target material. The smallest cross-section in the 3n channel is around 0.5 pico barn ($E^* \sim 35$ MeV).

We also calculate the production cross-section for the heavier isotopes of Livermorium produced in the ^{48}Ca+^{250}Cm reaction. The element ^{293}Lv is also the α decay daughters of the ^{297}118 through the reaction proposed above. Fig.2 presents the results for the production cross section for the reaction

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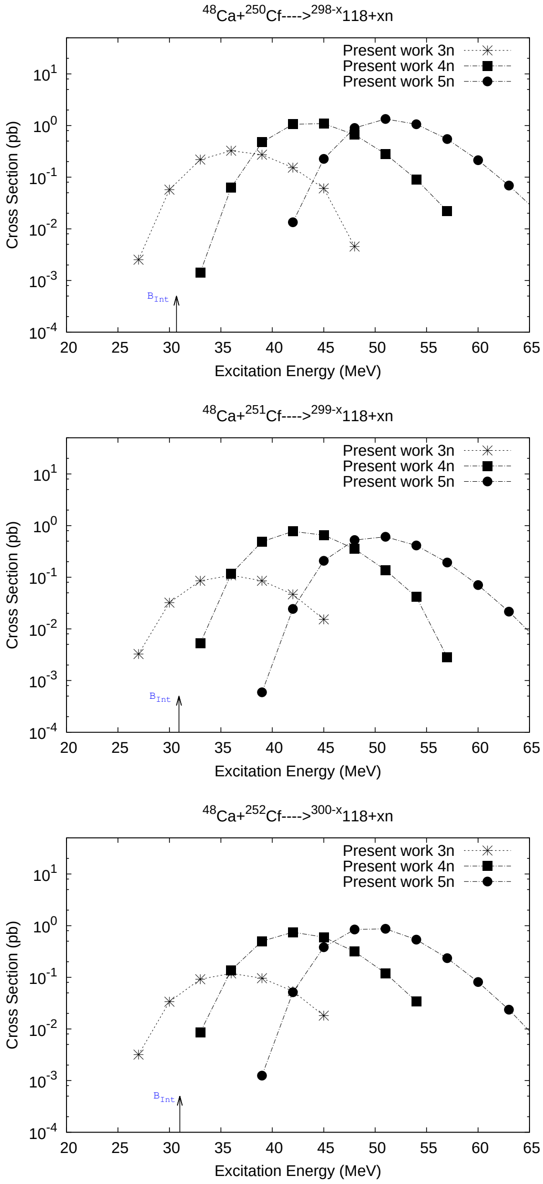

FIG. 1: Excitation energy (E*) dependence of the evaporation residue cross sections for the $^{250-252}$Cf(^{48}Ca,xn) reaction, leading to the synthesis of various isotopes of the element Z = 118.

^{48}Ca+^{250}Cm leading to the isotopes of livermorium Z=116 with mass number A=293, 294 and 295. The maximum (∼55 pico barns at E* ∼ 51 MeV) cross-section is for the 5n channel, while for the 4n channel it is of the order of 20

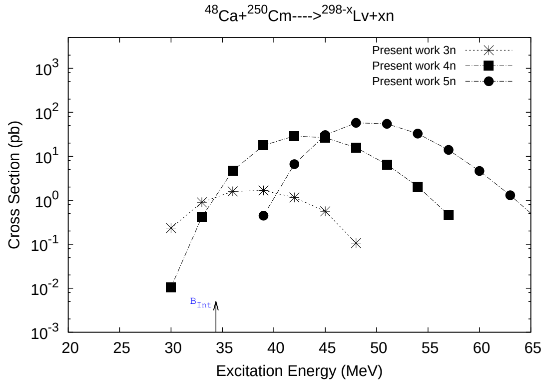

FIG. 2: Excitation energy (E*) dependence of the evaporation residue cross sections for the ^{250}Cm(^{48}Ca,xn) reaction, leading to the synthesis of various isotopes of the element Z = 116.

pico barns at E* ∼ 43 MeV. For the 3n channel, it is around 1 pico barn at E* ∼ 39 MeV. STATE SOMETHING ABOUT THE SHAPE OF THE ex FUNC

These results may be useful to future experiments which use $^{249-252}$Cf isotopes for the target with a ^{48}Ca beam.

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