Physics Letters B 808 (2020) 135626

Contents lists available at ScienceDirect

Physics Letters B

www.elsevier.com/locate/physletb

Zeptosecond contact times for element Z=120 synthesis

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ARTICLE INFO

Article history:
Received 29 May 2020
Received in revised form 13 July 2020
Accepted 13 July 2020
Available online 17 July 2020
Editor: B. Blank

Keywords:
Superheavy-element formation
Z=120
Quasifission

ABSTRACT

The synthesis of new superheavy elements beyond oganesson (Z=118) requires fusion reactions with projectile nuclei with proton numbers larger than that of ^{48}Ca (Z=20), which has been successfully employed for the synthesis of elements with Z=112-118. In such reactions, fusion is drastically hindered by fast non-equilibrated dynamical processes. Attempts to produce nuclei with Z=120 using the ^{64}Ni+^{238}U, ^{58}Fe+^{244}Pu, ^{54}Cr+^{248}Cm, and ^{50}Ti+^{249}Cf reactions have been made, which all result in larger Coulomb forces than for ^{48}Ca-induced reactions, but no discovery has been confirmed to date. In this work, mass and angle distributions of fission fragments from these reactions have been measured with large angular coverage to aid in selection of the most promising projectile-target combination that would favor fusion. The results yield information on reaction contact times, with the longest exhibited by ^{50}Ti+^{249}Cf.

1. Introduction

The search for new elements represents one of the main focus points of physics research. To date, all of the elements with atomic number Z≤118 have been discovered, accessing the locality of the so-called island of stability - a region of superheavy nuclei (SHN) with enhanced stability due to shell closures, predicted more than half a century ago [1,2]. Expectations of the locations of these shell closures vary, with early calculations predicting 'new' magic shells to appear at Z=114 and N=184 [3]. Most modern calculations predict closed proton shells at Z=114, 120, 124 or 126 and a neutron shell closure at N=172 and/or 184 (e.g., [4–8]). No clear indications of such a shell closure at Z=114 have yet been observed, giving a strong motivation to push to ever-heavier elements.

New beam and target combinations must be explored to reach beyond Z=118 as doubly-magic ^{48}Ca projectile ions, successfully used in fusion-evaporation reactions for the production of elements with Z=112-118 [9–24], cannot presently be used due to insufficient amounts of target material with Z>98 [25]. Campaigns totaling about one year of accelerator beamtime searching for the element with Z=120 have been carried out using the ^{64}Ni+^{238}U [26], ^{58}Fe+^{244}Pu [27], ^{54}Cr+^{248}Cm [28,29] and ^{50}Ti+^{249}Cf [30,31] fusion-evaporation reactions. Despite this, element Z=120 remains undiscovered, suggesting that production cross sections are lower than those for ^{48}Ca-induced reactions. However, the important question of how much lower the production cross sections are remains unanswered, which is a critical issue for the planning of successful future SHN experiments.

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https://doi.org/10.1016/j.physletb.2020.135626
0370-2693/