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Precompound charged particle emission (PCE) — a mechanism beyond element production by complete fusion

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Abstract. Complete fusion reactions (xn-channels) using actinide targets are observed for values of the effective fissilities $x_{eff} \sim 0.80$ in the sub-pb range of production cross sections. The elements produced at this limit are $Z = 108$–112. Beyond complete fusion, heavier elements might still be produced by reaction mechanisms releasing part of the nuclear charge before an equilibrated compound system might have been reached. Precompound Charged particle Emission (PCE) is proposed as a possible mechanism following complete fusion. A scheme delivering isotopes of elements $Z = 110$–115 is discussed, and experimental evidence for such a process is presented. Compound systems, the atomic numbers of which are smaller than in complete fusion reactions, might be produced in ^{48}Ca induced reactions on actinides with larger cross sections than those at the limits of complete fusion. Besides complete fusion, the PCE-mechanism should be considered as an alternative to interpret the ^{48}Ca-induced reactions on actinides.

PACS. 25.60.Pj Fusion reactions – 25.70.Gh Compound nucleus – 25.70.Pq Multifragment emission and correlations

1 Note to the retraction of the submitted paper

The manuscript *Precompound Charged Particle Emission (PCE) — A Mechanism beyond Element Production by Complete Fusion* has been retracted by the author in view of new experimental results [1]. The author explains in the following note why — six months after the workshop at Frauenwörth in September 2006 — it became evident that Precompound Charged particle-Emission is of no concern for complete fusion reactions of ^{48}Ca on actinides previously observed at FLNR, Dubna [2], and presented by Oganessian to the workshop [3].

2 Status September, 2006

As stated at the workshop on September 27, 2006, the final impetus to submit a paper on Precompound Charged Particle-emission came from recent results in May 2006 by the PSI-FLNR collaboration [4,5]. They used a chemical method to separate isotopes of element $Z = 112$ produced in ^{48}Ca-induced reactions in ^{238}U- and ^{242}Pu-targets. The earlier finding [2] to synthesize with a 2.5 pb cross section an isotope of $Z = 112$ decaying within 4s by α-emission (9.54 MeV) and a subsequent spontaneous fission of 0.2 s formed in the reaction ^{48}Ca/^{238}U could not be confirmed either by experiments at LBL [6,7] and GSI [8,9] nor by the above $Z = 112$ chemical separation method. The limit of production cross section of the many unsuccessful searches approached 0.3 pb, far below the published cross section. Replacing the ^{238}U-target by a ^{242}Pu-target in the chemical experiment [5] gave a surprise. The searched for decay chain was found twice. In the experiment, isotopes of element $Z = 114$ could not be detected, as the chemistry was sensitive to isotopes of element $Z = 112$ only. The detected decay-chains either followed the undetected decay of short-lived isotopes of element $Z = 114$, or they were produced by an (α, xn)-reaction. The separation of the two reaction mechanisms was not possible by the chemical technique used, but undoubtedly the observed decay-chains had to be assigned to element 112. At the workshop I discussed the possible production in the reaction ^{48}Ca/^{242}Pu by the PCE-mechanism followed by later $2n/3n$-emission from the $Z = 112$ compound system. Such a reaction mechanism was observed already in 1990 investigating fusion of mass-symmetric collision partners in an experiment producing Th-isotopes from the Pd/Pd reaction [10].

3 Status March, 2007

Since our workshop six months passed, and new experimental evidence is available showing that the PCE-hypothesis is not applicable to the ^{48}Ca/^{238}U-reaction.

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At GSI, Darmstadt, in a third ^{48}Ca/^{238}U search experiment the SHIP-separator detected two of the above mentioned decay-chains [1]. SHIP exploits the kinematics of complete fusion, that is the forward-emission into a very restricted element of solid angle, and the well-defined velocity of the reaction residue. A kinematical separator like SHIP suppresses $x\alpha$-reactions with their broadened angular distribution by a large factor. The fact having found the decay-chains finally confirms the earlier Dubna experiment [2]. Moreover, as produced with a sizable cross section of about 1 pb, the origin of the chains from a complete fusion reaction, becomes compulsory. Why did all the former search experiments fail, and only the third effort at GSI did succeed? At the fusion barrier the width of an excitation function may get very narrow. The channel at the barrier is a $3n$-channel and to find the correct energy of the projectiles would be difficult. A mass assignment to $A = 283$ in agreement with its former assignment at Dubna thus would be supported even by the many former negative results.

4 Conclusion

Together with the PSI-FLNR assignment of the decay-chains to element $Z = 112$, the SHIP-result confirms complete fusion of ^{48}Ca and ^{238}U and the synthesis of ^{283}112 in a $3n$-channel. To transfer the finding of complete fusion to all reactions investigated at Dubna [3] is an obvious assumption, as well as to link the cross bombardments to ^{283}112, the assignment of which by independent experiments is assured now.

Oganessian and his team discovered at least four new elements and about 30 new isotopes. The independent confirming experiments [1,5] destroyed my former standing doubts in their work, which I formulated also in the retracted paper. In this note I want to convey my congratulations for their outstanding discoveries of the last years, late, but by full heart.

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