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SHE synthesis experiments at Dubna

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Results of experiments on the synthesis of superheavy nuclei in 48Ca-induced reactions are presented. The experiments were carried out at the Flerov Laboratory of Nuclear Reactions (FLNR) of the Joint Institute for Nuclear Research (Dubna) in the framework of a large collaboration with IAR (Dimitrovgrad, Russia), LLNL (Livermore, USA), ORNL (Oak-Ridge, USA).

In fusion reactions of doubly magic 48Ca with actinide isotopes one can approach a region of theoretically predicted superheavy nuclei, stabilized by the influence of closed p- and n-shells with Z = 114 (or Z = 120, 126) and N = 184.

The experiments started at the FLNR in 1998 using VASSILISSA electromagnetic and the Dubna gas-filled recoil separators. Beams of accelerated 48Ca ions with intensity up to 1013 s-1 were produced by the U400 heavy ion cyclotron. Enriched isotopes of U ÷ Cf were used as targets. In reactions studied in 2000 – 2011, the new heaviest isotopes of Rf, Db, Sg, Bh, Hs, Mt, Ds, Cn and isotopes of six new elements 113 ÷ 118 were produced and studied.

The new isotopes populate an isolated island, which has no connection with the region of known nuclei. Thus for their unambiguous identification the analysis of generic decay links, properties of α-decays, spontaneous fission and cross-bombardments have been employed. Significant part of Dubna experiments has been reproduced in GSI (Germany) and LBNL (USA). The discovery of the elements 114 and 116 has been recognized by the IUPAC in June 2011 [1].

For more detailed study of newly synthesized nuclei improvements in accelerator, target and separation techniques are necessary. Now at FLNR JINR so-called SHE-factory (new accelerator complex on the basis of powerful DC280 cyclotron) is constructed. It will be able to produce heavy ion beams (A>40) with intensities about 5·1013 pps.

The heaviest target which can be used in practice is a 251Cf one. Thus 296118 is the heaviest nuclide which can be produced in fusion reactions with 48Ca. To study heavier nuclei one must investigate reactions with heavier ions like 50Ti, 54Cr, 58Fe. Intensively discussed are also reactions with radioactive nuclei and deep inelastic transfer reactions.

In the close future it is planned to perform model experiments using method of high resolution alpha spectroscopy and gamma quanta detection to study decay properties of the Rf and Db in the reactions 50Ti + 208Pb → 257Rf + 1n and 50Ti + 209Bi → 258Db + 1n.

These experiments will help us to prepare full scale spectroscopy experiments aimed to the study of decay properties of the isotopes in the decay chains of 288/115 and 287Fl formed in the complete fusion reactions 48Ca + 243Am → 288115 + 3n and 48Ca + 242Pu → 287Fl + 3n.

References

[1] Pure Appl. Chem., Vol. 83, No. 7, pp. 1485–1498, 2011.

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