Progress in half-lives measurements of heavy neutron-rich nuclei approaching the r-process path around N=126

T. Kurtukian-Nieto[1], J. Benlliure [1], K-H. Schmidt[2], E. Casarejos [1], M. Fernandez-Ordoñez [1], J. Pereira[1], L. Audouin[3], F. Becker[2], B. Blank[4], J. Giovinazzo[4], D. Henzlova[2], B. Jurado[4], F. Rejmund[5], O. Yordanov[2]

[1] *Universidad de Santiago de Compostela, E-15782 Santiago de Compostela, Spain*
[2] *Gesellschaft für Schwerionenforschung mbH (GSI), D-64291 Darmstadt, Germany*
[3] *Institut de Physique Nucléaire, F-91406 Orsay cedex, France*
[4] *CENBG, F-33175 Gradignan, France*
[5] *GANIL, Bd. Henri Becquerel, BP 55027, 14076 Caen Cedex 5, France*

The astrophysical rapid-neutron-capture process, or r-process [1], is responsible for the synthesis of roughly half the heavy nuclei in the solar system. The dominant features in the solar r-process abundance distribution are large peaks at the nuclear mass numbers A=80,130,195. The location of this peaks is related to the neutron-closed-shell nuclei, the so called waiting point nuclei, which capture neutrons reluctantly and have long beta decay lifetimes, acting as bottlenecks at which abundances build up. The study and knowledge of the structure and decay properties of those nuclei is important because they determine the r-process time scale at the r-process 'ladders' (N=50, 82, 126) and therefore could help to understand how, when and where this nucleosynthesis process takes places.

One of the main problems the nuclear astrophysicists have to face is the lack of information available for heavy neutron-rich nuclei, most of them still unknown. During the last years promising results have been obtained investigating the properties of medium-mass neutron-rich nuclei close to the waiting point N=82 while the waiting point around N=126 remains a completely unexplored territory. Fortunately the situation is changing and recent experiments performed with heavy ions at relativistic energies have shown the possibility to produce heavy neutron-rich nuclei by means of cold-fragmentation reactions [2].

In this work we report on an experiment performed with the FRS at GSI to measure the beta decay half-lives of heavy neutron-rich nuclei close to the neutron shell N=126. These nuclei were produced by cold-fragmentation reactions induced by ^{208}Pb projectiles at 1 A GeV impinging a Be target. The isotopic identification was achieved by determining both the atomic number and the mass-over-charge ratio of each nucleus by means of the measurements of the magnetic rigidities, time of flight and energy loss of each fragment passing through the FRS. The identified nuclei were implanted on an active catcher made of four 5x5 cm2 Double-Side Silicon Strip Detectors. The position and time correlation between the implanted nuclei and the subsequent beta decay allowed us to determine their half-lives.

In this experiment we were able to measure for the first time the half-lives of several neutron-rich isotopes of iridium, osmium, rhenium, tungsten and tantalum approaching the waiting point N=126. These half-lives have been compared with model calculations, Gross Theory [3] and QRPA [4] which in general do not reproduce the measured data.

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