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Stellar nucleosynthesis and superheavy nuclei in our Universe and in the lab!

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The heaviest element which has been found in nature is uranium with 92 protons. So far, the elements up to atomic number 118 (oganesson) have been discovered and synthesised in the laboratory and the last one was named after the physicist Y. Oganessian in 2016. All transuranium elements are radioactive and their production rates decrease with increasing number of protons. An Island of Stability, where the nuclei have relatively long half-lives, is predicted at the neutron number 182 and, depending on the theoretical model, at the proton number 114, 120 or 126. Current experimental techniques do not allow to go so far to the neutron-rich side close to the Island of Stability. The observation of gravitational waves as well as electromagnetic waves originating from a neutron star merger has been published on October 16, 2017 and is a first proof of the nucleosynthesis of heavy elements in the r-process. It still remains an open question if superheavy nuclei have been formed in our universe. To answer these questions, we need insight into the nuclear properties of the heaviest elements and how these properties evolve when one moves toward to the neutron-rich side on the nuclear chart. During my PhD thesis, I set out to discover new, neutron-rich heavy nuclei using multi-nucleon transfer reactions. These studies will provide insight into the evolution of nuclear shells in the heavy element region.

In 2019, I have proposed and performed a first preliminary experiment at Argonne National Laboratory (close to Chicago, USA) to investigate deep-inelastic reactions mechanisms in the heavy elements region. We accelerated a beam of ^{136}Xe on a ^{238}U target with energy about 705 MeV and velocities close to 10% of the speed of light in vacuum. the Gammasphere 4π germanium-array coupled to the AGFA (Argonne gas-filled analyzer) separator with the implantation-decay station (PPAC, DSSD and silicon tunnels) and germanium clover detectors XArray at the focal plane aim at identify our nuclei of interest (prompt and delayed γ-spectroscopy…). For the first time, we performed a deep-inelastic reaction at 0° using AGFA to produce heavy U-like nuclei. The separation with the beam Xe-like nuclei was a great success and we saw the first nucleon exchanges in this process and shows that this is a new pathway towards the synthesis of new super heavy neutron-rich isotopes.

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Auteur principal: Mlle FAVIER, Zoé (CEA-Saclay / Irfu)

Co-auteurs: Dr SULIGNANO, Barbara (CEA-Saclay / Irfu); Dr DROUART, Antoine (CEA-Saclay / Irfu)

Orateur: Mlle FAVIER, Zoé (CEA-Saclay / Irfu)

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