Structure and limits of the superheavy nuclear quantum building

(Internship and Thesis)

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The atomic nucleus and quantum mechanics still hold many secrets for us that we can reveal through experiments at the limits of the capabilities of our instruments. Situated at the extreme mass limit of the nuclide chart, superheavy nuclei represent one of the major scientific challenges of the 21st century: is there an ultimate island of nuclear stability? How many new elements can we still synthesize? What conclusion can we draw from this about nuclear cohesion?

To date, the heaviest element observed is Z=118 with only five nuclei observed (3 in 2006 and 2 in 2012). These ^{294}Og nuclei were produced in Dubna, Russia, by fusion of ^{48}Ca (Z=20) and ^{249}Cf (Z=98) nuclei followed by evaporation of 3 neutrons. The most difficult element to discover was Z=113 (Nihonium). It took our Japanese colleagues 3 years of cumulative beam over 9 calendar years to observe 3 nuclei and validate the discovery of the element!

Elements 119 and 120 will be placed on a new period of Mendeleev's table opening the possibility to study *g* electronic shels. Their discovery requires intense isotopic beams of ^{50}Ti (Z=22), ^{51}V (Z=23), and ^{54}Cr (Z=24) and installations able to produce them. Thanks to his expertize, the DNE group is presnent on these 3 programmes. They should lead us to discover new elements in the close coming years.

The quantal structure of the nucleus can also be studied via spectroscopic measurements. Within this framework, our team carried out in 2011 at the University of Jyväskylä (Finland) the first prompt spectroscopy of a superheavy nucleus, the ^{256}Rf (Z=104). We were able to establish the rotational structure of this nucleus [1, 2, 3] and confirm the presence of three K isomers [4]. These K isomers have the peculiarity of signing the nucleonic quantum states. Our team continues the study of these isomers with the ensemble S^3 + SIRIUS wo will get his first beams at GANIL.

The M2 trainee will become familiar with data analysis techniques based on genetic correlations. He will develop his raw data analysis code that will allow him to access the spectroscopic properties of transfermian nuclei studied. He will also be able to learn how to search for chains of decreases in our superheavy data.

Half of the thesis will be devoted to the synthesis of new elements with the search of 119 in RIKEN (Japan) and the search of 120. The second half will be devoted to the study of isomers in superheavy nuclei, including the new focal plane system SIRIUS wo will get his frist beams at GANIL during the thesis.

[1] Rubert J., Piot J., Asfari Z., Gall B.J.P., et al., (2012) Nucl Instr and Meth B 276 (2011) 33–37
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[3] Gall B. & Greenlees P.T., Nucl. Phys. News 23 #3 (2013) 27-31
[4] Rubert J., Gall B.J.P., Dorvaux O., Greenlees P.T., Asfari Z. et al., to be published.