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Formation of Super-Heavy Elements: Uncertainties in Theoretical Modeling

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One of the biggest challenges in nuclear physics is to synthesize new super-heavy elements (SHE) and thus to extend the periodic table. It is commonly known that SHE cannot be found in nature. According the shell model, they have been predicted to exist thanks to a regain of stability. Experimentally, by making use of heavy-ion collisions, SHE can be artificially produced in laboratories. However, owing to extremely low formation probabilities, such experiments become increasingly difficult. More powerful experimental set-ups are therefore needed to overcome this issue. For instance, within the promising project SPIRAL2 at GANIL, the study of super-heavy elements has been selected as one of priority research subjects for the coming years.

On the other hand, the complete reaction mechanism for the synthesis of super-heavy elements still remains unclear. One of the most serious problems is the so-called fusion hindrance phenomenon that is well understood only qualitatively but not quantitatively. Many theoretical attempts have been made over the past few decades. However, there exist large discrepancies in the predictions provided by different theoretical models. More concretely, this might be due to either uncertainties in model parameters or models themselves. Hence, a natural question arises: How to clarify both uncertainty contributions so as to constrain the fusion models?

Using the Monte-Carlo method, we tried to estimate the uncertainties related to the parameters entering the model, in order to investigate whether they can explain such discrepancies observed among various fusion models. Here, we mainly focused on the last phase of the reaction, namely statistical decay of the compound nucleus, by means of the KEWPIE2 code.

Moreover, we only have access to very few and poor experimental data. Another interesting question needed to be addressed is that, what can we learn about model parameters from experimental data? As an inverse problem, Bayesian statistics would be a perfect candidate. I will also give a brief introduction to this theory as well as some simple applications. Our recent work will be presented at the end of this talk.

Auteur: M. LÜ, Hongliang (GANIL and Normandie University)

Co-auteur: Dr BOILLEY, David (GANIL and Normandie University)

Orateur: M. LÜ, Hongliang (GANIL and Normandie University)

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