What are the chances of synthesizing elements 119 and 120?

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One of the challenges in low-energy nuclear physics is the synthesis and study of new superheavy nuclei (SHN). Systematic experimental research performed over the past 30 years has led, with the discovery of element 118, oganesson, to the completion of the 7th row of the periodic table. Unfortunately, experimental attempts to go beyond Og have not been successful so far, mainly due to the extremely low production cross sections. The experiments indicate that the synthesis cross sections for elements 119 and 120 may be extremely low, even as low as a few femtobarns. This emphasizes the critical need for accurate predictions of the optimal colliding system and bombarding energies.

This talk will provide an overview of the results obtained within the Fusion-by-Diffusion (FBD) model [1] for performed, ongoing, and planned experiments which could lead to the synthesis of elements 119 and 120. Special attention will be paid to two complementary reactions, ^{50}Ti + ^{249}Bk and ^{51}V + ^{248}Cm, leading to the same compound nucleus, ^{299}119. The first reaction was already studied in GSI, resulting in the 65 fb upper limit, while the second is currently under study in RIKEN. Differences in these two reactions, in both the entrance channel and fusion step of the process, will be discussed in detail. Predictions of the evaporation residue cross sections will also be presented.

Calculations were performed assuming that the evaporation residue cross section can be described as a product of three factors: the capture cross section, the fusion probability, and the survival probability. The merging of the colliding projectile and target nuclei is described as a diffusion process. The survival probabilities were obtained using new nuclear data tables for SHN [2], providing a consistent set of masses, deformations, fission barriers, and shell corrections.

[1] T. Cap, M. Kowal, and K. Siwek-Wilczyńska, Eur. Phys. J. A 58, 231 (2022)
[2] P. Jachimowicz, M. Kowal, and J. Skalski, At. Data. Nucl. Data. Tables. 138, 101393 (2021)