Stepping towards the Island of Stability

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The superheavy nuclei (SHN, with atomic number Z >= 104) exist entirely because of the shell effects. In the classical liquid-drop model, these nuclei would fission spontaneously due to their large electric charge. The shell effects create a fission barrier, nonexistent in the liquid-drop picture, guaranteeing their survival. The stabilizing effects of the nuclear shells also imply the existence of very long-lived superheavy nuclei with large proton and neutron numbers where these effects are stronger. This region of enhanced stability is called the island of stability. However, the position of this island is not certain as different nuclear models predict differently. Macroscopic-microscopic models (using Nilsson, Woods-Saxon, or folded Yukawa potentials) predict the center to be at Z = 114, N = 184 [1,2] while the self-consistent models using Skyrme, Gogny, or relativistic mean field effective nuclear interactions predict it to be at Z = 120, 124, 126 and N = 172, 184 [3–6], depending on the parametrization used in the calculations. The SHN are normally produced in fusion-evaporation reactions with very low production cross sections ($\approx$ 10 nb in the A = 250 region). The cross section diminishes even more as a function of atomic number [7]. As a result, the available spectroscopic data in the transfermium region are still rather scarce [8]. Performing detailed spectroscopy in the lighter transfermium region is thus more pragmatic and one step closer to understanding the properties of the SHN. To refine the theoretical models, their predictions can then be compared against detailed spectroscopic information on these nuclei. One such viable experimental approach is to search for and study low-lying metastable states, since their decay properties depend on the nature of the states available at the Fermi surface. In the A = 250 region, high K isomers have been identified in several isotopes. We performed an experiment to investigate the presence of high K isomers in ^{255}Rf using the GABRIELA [9] setup at the focal plane of SHELS [10] separator at the FLNR facility in Dubna. In this seminar, I will first present the results concerning the three isomeric states observed in ^{255}Rf and also its α-decay to ^{251}No. In the second part of the talk, I will discuss about our attempts to study the excited states in ^{252}Fm nuclei at the Argonne National Laboratory using the FMA [11] recoil separator and the GRETINA [12] gamma-ray detector array. ^{252}Fm being deformed and doubly-magic makes it a very interesting case to investigate the effects of shell closure on nuclear structure. In the third part of the talk, I will present the current status of the SIRIUS (Spectroscopy and Identification of Rare Isotopes Using S^3) [3] detector array which will be placed at the focal plane of S^3 (Super Separator Spectrometer) [14] to study rare isotopes like superheavy and exotic nuclei far from the stability with very low production cross-sections.

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