

6-3 How Far Does the Area of Superheavy Elements Extend? — Decay Modes of Heavy and Superheavy Nuclei —

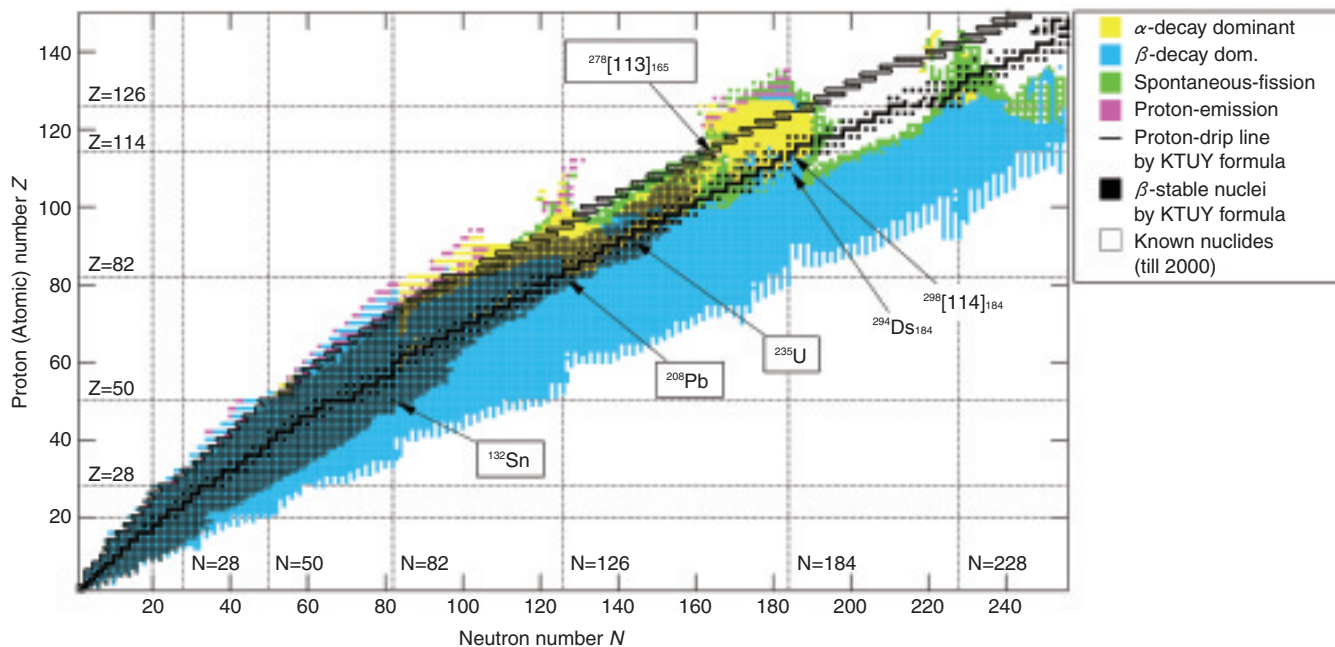


Fig.6-4 Dominant decay mode of nuclei: α -decay, β -decay, spontaneous fission or proton emission

The nuclear decay mode with the shortest partial half-life among probable nuclear decays, the dominant decay mode, is shown for each nucleus. We consider four decay modes, namely, α -decay, β -decay, proton emission and spontaneous fission in this calculation. Only nuclides with half-lives of 1 nanosecond or longer are plotted.

Nucleus is a composite system consisting of protons and neutrons, and approximately 3000 nuclides have been identified. However, the existence of much more nuclides is postulated theoretically. How far the area of nuclei extends is an essential and important question in nuclear physics.

We have developed an original model based on the macroscopic and mean-field models to describe the global features of nuclear masses, called the KTUY (Koura-Tachibana-Uno-Yamada) nuclear mass model. By using the KTUY model, we have studied decay modes for α -decay, β -decay, proton emission and spontaneous fission ranging from light nuclei to superheavy nuclei including unknown ones, and estimated the dominant nuclear decay modes as shown in Fig.6-4. This figure shows the existence of an “island of

stability for the superheavy nuclei” around $^{298}[114]_{184}$. We also could obtain the nucleus with the longest total half-life among neighboring nuclei, $^{294}\text{Ds}_{184}$ ($Z=110$), which is on the β -stability line of our model. This is an α -decay-dominant nucleus, and has a half-life on the order of 100 years.

We also estimated decay modes of nuclei beyond the superheavy ones and find the next “island of stability” on $N=228$ line in the neutron-deficient region. This is caused by the larger fission-barrier height due to the shell closure with 228 neutrons. Another region with similar tendency is found near $N=126$ outside the proton-drip line. On the neutron-rich side, nuclei are mostly β -decay dominant and have relatively long total half-lives, at least on the order of 1 ms.

References

- Koura, H. et al., Nuclidic Mass Formula on a Spherical Basis with an Improved Even-Odd Term, Progress of Theoretical Physics, vol.113, no.2, 2005, p.305-325.
- Koura, H. et al., How Far does the Area of Superheavy Elements Extend? — Decay Modes of Heavy and Superheavy Nuclei Predicted by a Mass Formula —, Nippon Butsuri Gakkai-shi, vol.60, no.9, 2005, p.717-724 (in Japanese).