Competetion between different decay modes of ^{318}126

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Introduction

The competition between different decay modes of superheavy nuclei, 126 with atomic mass 318 is a fascinating area of nuclear physics [1]. Superheavy elements exist at the edge of nuclear stability and are primarily synthesized in laboratories through fusion reactions. These elements reside beyond the so-called "island of stability," where the balance between protons and neutrons becomes increasingly delicate. As a result, they exhibit complex decay patterns that are critical to understanding their properties [2].

^{318}126 is expected to undergo multiple types of decay due to its extreme proton number and neutron richness. The most common decay modes for superheavy elements include alpha decay, spontaneous fission, and in some cases, beta decay or electron capture [3]. The competition between these decay modes depends on various factors such as nuclear structure, energy levels, and the relative probability of each decay pathway. Studying these decay modes provides insights into the stability and lifetime of superheavy elements and aids in predicting the properties of as-yet-undiscovered isotopes. Understanding these decay mechanisms is crucial not only for exploring the limits of the periodic table but also for advancing theoretical models of nuclear structure and reaction dynamics in the superheavy region.

Theory

Alpha decay, cluster emission and heavy particle radioactivity half-lives are evaluated by [4-5],

$$T_{1/2} = \frac{\ln 2}{\upsilon_o P}$$

Where υ_o assault frequency and P is barrier penetration probability.

Spontaneous fission half-lives are evaluated by

$$T_{1/2} = \exp[2\pi(C_o + C_1 A + C_2 A^2 + C_3 Z^4 + C_4 (N-Z)^2) - (0.13323 Z^2 / A^{1/3} - 11.64)]$$

Where C_o,C_1,C_2,C_3 and C_4 are constants [6]. Z and A are atomic and mass numbers of parent nucleus.

Results and Discussions

The figure illustrates the alpha decay chain of the superheavy isotope ^{318}126. The decay chain begins with ^{318}126 undergoing alpha decay to produce ^{314}124, with a logarithmic half-life of -6.859s and a Q-value of 14.455MeV. This process continues through subsequent alpha decays, resulting in the formation of ^{310}122, ^{306}120, and ^{302}Og, with Q-values ranging from 12.845MeV to 15.105MeV. The chain terminates at ^{298}Lv, which spontaneously fissions with a logarithmic half-life of -8.403s. The consistent pattern of alpha decays is evident, with relatively high decay energies, particularly in the decay from ^{310}122 to ^{306}120, where the Q-value peaks at 15.105MeV. The decreasing half-lives, which are all negative logarithmic values, indicate rapid decays occurring in milliseconds.

The decay modes of these superheavy nuclei reflect the complex interplay between alpha emission and spontaneous fission, with alpha decay being the dominant mode throughout the chain until ^{298}Lv, where spontaneous fission becomes the preferred decay mechanism. This shift highlights how the competition between different decay modes evolves as the nucleus becomes lighter and more fissile. The relatively short half-lives and high Q-values suggest that the nuclei are highly unstable, shedding both energy and mass rapidly to achieve stability. The clear sequence of decay provides valuable insights into the nuclear structure of superheavy elements and helps refine theoretical models predicting the behavior of isotopes near the so-called "island of

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stability." Understanding these decay chains is critical for ongoing research in the synthesis and characterization of new superheavy elements.

We also evaluated the half-lives for clusters as well as heavy particles and the results are tabulated in the table 1. In this table we mentioned the logarithmic half-lives less than LogT<10.

Table 1: Decay modes, corresponding Q values and logarithmic half-lives of compound nucleus ^{318}126.

Decay modes	Q(MeV)	LogT$_{1/2}$(s)
α	14.455	-6.859
^{14}C	53.32	5.140
^{20}O	74.12	7.039
^{22}Ne	96.42	5.988
^{30}Mg	116.95	6.225
^{74}Ge	291.53	1.971
^{75}As	291.25	6.632
^{80}Se	308.85	-1.820
^{79}Br	300.68	8.394
^{84}Kr	319.94	-1.235
^{85}Rb	318.96	2.987
^{88}Sr	330.56	-1.159
^{89}Y	328.92	3.031
^{90}Zr	331.15	4.861
^{93}Nb	334.24	5.757
^{98}Mo	349.37	-1.106
^{97}Tc	340.04	7.433
^{102}Ru	358.46	-1.732
β+	9.248	-5.146
SF	-	-4.938

Conclusion

The decay modes of the superheavy isotope ^{318}126 reveal a complex interplay between alpha decay and spontaneous fission. Alpha decay dominating until the nucleus reaches ^{298}Lv, where fission prevails. Firstly the parent nucleus undergo series of five alpha decays and end up with spontaneous fission. The rapid decays, indicated by short half-lives and high Q-values, underscore the extreme instability of these nuclei as they lose energy and mass to approach stability. Studying these decay chains provides crucial insights into nuclear structure and informs theoretical models for predicting the behavior of superheavy elements, particularly near the "island of stability," where longer-lived isotopes may exist.

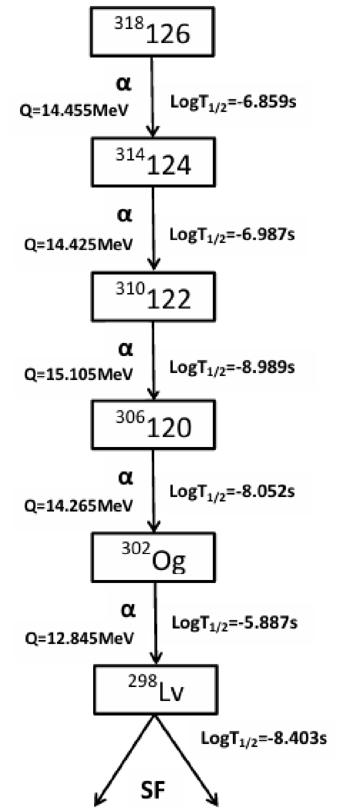

Fig. 1 Decay chain of a compound nucleus ^{318}126. .

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