α-decay of $^{265}_{106}Sg$ and $^{261}_{104}Rf$ revisited

M. Gupta[1]*, A. Bhagwat[2], and Y. K. Gambhir[3]
[1]*Manipal University, Manipal - 576104, INDIA*
[2]*Department of Physics, IIT-Gandhinagar, Ahmedabad – 382424, INDIA*
[3]*Department of Physics, IIT-Powai, Mumbai - 400076, INDIA*
* *email: mohini.gupta@manipal.edu*

Introduction

Following theoretical predictions of deformed regions of stability around Z=108 and N=162, the mid-1990's were witness to the start of a series of experiments aimed at uncovering the physics of this mass region. Due to the effect of the hypothesized shell closures, it was expected that the measured isotopes traversing the region would be relatively long lived. With on-going experimentation to study both nuclear and atomic aspects with their sometimes conflicting results, the nuclides ^{265}Sg and ^{261}Rf are of special interest.

Since nuclear physics experiments were primarily focused on measuring the properties of the decay products, investigations relied on identifying the decay daughters by comparison with known properties of descendents. It was therefore very important to measure decay times (half-lives) and alpha energies (Q-values) as accurately as possible. Atomic physics studies, on the other hand, were designed primarily to measure chemical properties such as the greatly increased volatility of chlorides of the trans-actinides (*i.e.* elements above Z=103). Hence, the experimental focus was mainly on the transmission of spontaneous fission (SF) activity through a suitable detection system indicative of the nuclide and chemical species of interest being formed (or its absence), rather than on the accurate measurement of a half-life. In both types of experiments, mass assignments were generally made relying on parent daughter correlations based on known decay properties. The substantial differences in the measurement techniques made it difficult for a conclusive identification.

Moreover, the presence of two states each in ^{265}Sg and ^{261}Rf (with one of the states unknown in early experiments) were not factored in for many initial mass assignments to the parents. This has contributed to the considerable confusion in the literature and in the adopted properties for these nuclides. Currently, following a complete re-examination of all experimental data[1] and an independent analysis of each experiment, the decay properties below have been suggested[2] as being the most likely taking into account the subsequent revision of all mass assignments to ^{265}Sg (^{261}Rf) which were earlier believed to originate from ^{266}Sg (^{262}Rf) whose properties stand revised via[3]. With new experiments underway to aid a conclusive assignment and clear the existing ambiguities, these two nuclides represent excellent candidates for theory to point the way.

Calculations, Results and Discussions

The relativistic mean field (RMF) calculations[4] with frozen gap approximation using axially symmetric deformed oscillator basis are carried out. The NL3 Lagrangian parameter set is used. The pairing gaps are obtained by reproducing the pairing energies of the relativistic Hartree–Bogoliubov (RHB) calculations. The ground state properties are well reproduced as expected. The α nucleus potential is generated in the double folding ($t\rho\rho$) approximation using RMF densities along with M3Y nucleon-nucleon interaction. This potential is then used in the WKB approximation to calculate the decay half-lives. The calculated as well as experimental Q-values are used. The results are arranged in Table 1. The calculated Q - values are smaller as compared to the experiment by ≈ 200 keV and the calculated decay half-lives are overestimated by a factor of 2–3. This is mainly due to the use of smaller values of Q. The agreement for half-lives improves when experimental Q values are employed supporting the current assignments to the respective ground states based on observations. It is noticed that the calculations predict $\frac{1}{2}^+$ as the ground state in both ${}^{261}_{104}Rf$ and ${}^{265}_{106}Sg$ and do not support the reversal[5] of $\frac{1}{2}^+$ and $\frac{9}{2}^+$ states based upon experimental data. However, several states appear within 200-300 keV above the ground state. Therefore, the possibility of a ground state other than $\frac{1}{2}^+$ is not ruled out.

References

[1] Ch. E. Dullman *et. al.*, PRC **77**, 064320, 2008 and references therein.

[2] www.nndc.bnl.gov/ensdf and references therein

[3] J. Dvorak *et al.*, PRL, **97**, 242501, 2006

[4] Y. K. Gambhir *et al.* Ann. Phys. (NY), **320**, 429, 2005.

[5] M. Asai, TAN07, 2007

	Q (MeV)		$T_{1/2}$ (s)		
Parent	Expt	RMF	Expt	RMF	RMF*
^{265}Sg	8.818	8.63	16.2	42.66	9.83
	8.965		8.9		3.26
^{261}Rf	8.411	8.24	78	213.8	45.38
	8.637		3.1		7.64

Table 1 : Calculated (RMF) Q values and half-lives ($T_{1/2}$) along with the corresponding experimental values for α-decay of ^{265}Sg and ^{261}Rf. The calculated half-lives using experimental Q values are denoted by RMF*.