



Theoretical study of the α -decay half-lives of $^{186-224}\text{Po}$ isotopes

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Abstract. The α -decay half-lives for $^{186-218}\text{Po}$ isotopes have been computed using Gamow-like model (GLM), Coulomb and proximity potential model (CPPM) including temperature-dependent proximity potential. The half-lives were evaluated using both experimentally and theoretically calculated Q -values. The computed α -decay half-lives are compared with experimental and empirical formulas such as Royer, universal decay law and the new Ren B formula. The standard deviations are evaluated and the results indicate that the GLM gives the best results for even–even nuclei, while the temperature-dependent CPPM gives the overall least deviation from experimental values. Among the empirical formulas, the Royer formula is the most suitable for the evaluation of α -decay half-lives for the Po isotopes considered.

Keywords. Alpha decay; half-life; Gamow-like model; proximity potential.

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1. Introduction

Alpha decay (α -decay) is a crucial decay mode that provides information about the nuclear structure and stability of heavy and superheavy nuclei [1]. It is important in the identification of new heavy and super heavy nuclei (SHN) [2], and in the study of nuclear force [3]. Investigations of the α -decay half-lives have been carried out both theoretically and experimentally using various approaches. Some of the theoretical models that have been employed to study the α -decay half-lives are the Coulomb and proximity potential model (CPPM) [4–7], the fission-like model [8], the generalised liquid drop model [9–11], the effective liquid drop model [12], the modified generalised liquid drop model [3,13,14], the preformed cluster model [15,16] and the Gamow-like model (GLM) [1,17].

An analytical formula to calculate the α -decay half-lives was developed by Royer [18] by applying a fitting procedure on a set of 373 nuclei. The universal decay law was developed by Qi *et al* [19,20]. They introduced the new universal decay law (UDL) to study α and cluster decay modes. They made use of the α -like R-matrix theory and the microscopic mechanism of the charged-particle emission. Ren *et al* [21] introduced a formula, a natural generalisation of the Viola–Seaborg formula, for cluster radioactivity half-lives. Recently, modified

versions of the Ren formulas were proposed [22]. They are named new Ren A and new Ren B. The new Ren A included nuclear isospin asymmetry while new Ren B included both nuclear isospin asymmetry and angular momentum.

The half-lives of some polonium isotopes have been studied in ref. [23] through α -decay. Using nuclear potentials, the α -decays from $^{186-224}\text{Po}$ have also been studied by Santhosh and Sukumaran [24]. Recently, the modified CPPM was employed to study the α -decay of $^{186-218}\text{Po}$ [25]. Cheng *et al* [1] studied the α -decay half-lives of nuclei with $Z > 51$ (up to $Z = 120$) using a modified GLM. Zdeb *et al* [17] proposed a phenomenological model which is based on the Gamow theory for the calculation of α -decay half-lives. In the GLM, the square well potential is chosen as the nuclear potential, while the potential of a uniformly charged sphere is taken as the Coulomb potential.

In this study, the GLM and the CPPM (with and without temperature-dependent proximity potential) have been used to calculate the α -decay half-lives of $^{186-218}\text{Po}$ isotopes using both experimentally and theoretically calculated Q_α values. The results are compared with the experimental values and values obtained from three empirical formulas, viz. the Royer formula, the universal decay law and the New Ren B formula.