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Benford's Law and Nuclear Isomer Half-lives

Newcomb discovered that natural datasets often exhibit a non-uniform distribution of leading digits, with smaller digits occurring more frequently. Benford later formalized this observation with a mathematical law, providing a precise formula for the expected distribution of the first significant digits based on logarithmic probabilities. Benford's law states the probability of a number starting with digit d is given by
\begin{equation}
P(d)=\log_d(1+1/d)
\end{equation}
In the domain of nuclear physics, Benford's first digit law has been applied to the half-lives of α-decay, β-decay, and spontaneous fission [1]. These half-lives are in excellent agreement with Benford's law, regardless of the type of interactions (viz. strong, weak, and electromagnetic) involved in the processes. To the best of the author's knowledge, datasets pertaining to γ decay half-lives have not yet been investigated in relation to Benford's Law. The present work illustrates the application of Benford's law to γ decay half-lives of nuclear isomers. The data used for the present study is taken from the Atlas of Nuclear Isomers [2].

A preliminary investigation reveals that the γ decay half-lives of nuclear isomers indeed follow Benford's law quite faithfully. For the first three significant digits, Benford's predicted distribution is less than the observed distribution (maximum deviation of 8%), while it is more than the observed distribution (maximum deviation of 17%) for the remaining six significant digits. All nuclei listed in the dataset are analyzed using Python's Pandas library. Nuclei with approximate/ tentative half-lives and half-lives listed with upper or lower limits are not included in the present analysis. A detailed analysis shall be carried out further in a systematic way with better cleaning and sorting of the data. A modular approach shall be incorporated by studying the pattern within each major shell. Possible physics behind the results and further plan of action with emphasis on possible AI technique implementation shall be discussed during the conference.

References

[1] Dongdong Ni and Zhongzhou Ren, Eur. Phys. J. A **38** (2008) 251.

[2] Swati Garg *et al.*, Atomic Data and Nuclear Data Tables **150** (2023) 101546.

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