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Nonliear mass-dependent corrections to King plots and their analysis

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King plots have long been used to extract information about relative nuclear charge radii from observed transition frequencies for three or more isotopes of the same element. They have also recently been proposed as a method to search for anomalies that may indicate new physics beyond the standard model [1]. However, an underlying assumption is that the normal and specific isotope shifts vary linearly with μ/M, where μ is the electron reduced mass and M is the nuclear mass. To test this assumption, we constructed synthetic King plots using as input high-precision theoretical atomic energy levels [2] for the isotopes of helium: He-3, He-4, He-6 and He-8. The results indicate that second-order mass polarization terms proportional to $(\mu/M)^2$ make a significant contribution and must be taken into account in the analysis of high precision spectroscopic data. Otherwise, they could masquerade as a signal for new physics. We propose a modified method of analysis (a super-King plot) that takes into account second-order mass polarization effects.
[1] V. V. Flambaum, A. J. Geddes and A.V. Viatkina, Phys. Rev. A **97**, 032510 (2018).
[2] G. W. F. Drake and Z.-C. Yan, Phys. Rev. A **46**, 2378 (1992).

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