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Effects of the Weak Quadrupole Moment in Atoms and Molecules

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Parity nonconservation (PNC) in atoms is a tiny weak interaction effect, arising largely from Z-boson exchange between atomic electrons and neutrons. This has been a rich area of study for the past few decades with the weak charge measured with up to a fraction of a percent precision, and the nuclear anapole moment experimentally observed once, with an uncertainty approaching 10%. Of recent interest, is the weak quadrupole moment (WQM), which leads to small changes in parity-violating amplitudes between hyperfine states in deformed nuclei (Flambaum, Dzuba, & Harabati, 2017).

Nuclei with a quadrupole deformation have an enhanced WQM which induces the tensor weak electron-nucleus interaction in atoms and molecules. Recently, it has been shown that in diatomic molecules containing an atom with a quadrupole deformation, the WQM can become the dominant contributor to the PNC amplitude (Skripnikov, Petrov, Titov, & Flambaum, 2019). Studying this moment in molecules presents a promising avenue for the experimental verification of the WQM, with ideal candidates already identified. Utilising relevant atomic and molecular theory, I calculate the PNC amplitude of the WQM for triply-ionised thorium which is an ion of recent interest in its own right. Additionally, I compute the PNC amplitudes for diatomic molecules containing thorium, which have been flagged as promising candidates for future high-precision measurements.

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