Variation of the Quadrupole Hyperfine Structure and Nuclear Radius due to an Interaction with Scalar and Axion Dark Matter

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Atomic spectroscopy is used to search for the space-time variation of fundamental constants which may be due to an interaction with scalar and pseudoscalar (axion) dark matter. In this letter, we study the effects which are produced by the variation of the nuclear radius and electric quadrupole moment. The sensitivity of the electric quadrupole hyperfine structure to both the variation of the quark mass and the effects of dark matter exceeds that of the magnetic hyperfine structure by 1-2 orders of magnitude. Therefore, the measurement of the variation of the ratio of the electric quadrupole and magnetic dipole hyperfine constants is proposed. The sensitivity of the optical clock transitions in the Yb⁺ ion to the variation of the nuclear radius allows us to extract, from experimental data, limits on the variation of the hadron and quark masses, the QCD parameter θ and the interaction with axion dark matter.

References

[1] V. V. Flambaum and A. J. Mansour, , Phys. Rev. Lett. 131, 113004 (2023).