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Searching for ultralight dark matter with spectroscopy of radio-frequency atomic transitions

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We report on ongoing experimental searches for fundamental constant (FC) oscillations which are motivated within models of ultralight scalar dark matter (DM). In one search, the frequency of a bulk acoustic-wave quartz oscillator is compared to the frequency of the ^{87}Rb ground-state hyperfine transition [1], to look for oscillations of the electron mass m_e, fine structure constant α, and nucleon mass m_N, in the frequency range 1.6 mHz-200 Hz (underlying DM particle mass range $6.9 \times 10^{-18} < m_\phi < 8.27 \times 10^{-13} eVc^{-2}$). In another search carried out in the same frequency range, a radio-frequency electronic transition in ^{164}Dy is probed to look for oscillations in the fine-structure constant [2], exploiting the extreme sensitivity of the transition frequency to changes of this constant. Preliminary results are presented, based on data from a 25-day long quartz-Rb run, and a 12-hr long Dy run. In the absence of detection of FC oscillations, we constrain the DM coupling to α, m_e and m_N. The constraints on α from the Dy experiment improve on previous results by as many as three orders of magnitude, while the results on the couplings to m_e and m_N from the Rb-quartz experiment improve on previous constraints by an order of magnitude in part of the explored parameter space.

[1] W. M. Campbell et al. PRL 126, 071301 (2021).
[2] K. V. Tilburg et al. PRL 115, 011802 (2015).

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