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Prospects of nuclear-coupled-dark-matter detection via correlation spectroscopy of I_2^+ and Ca^+

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The nature of dark matter (DM) and its interaction with the Standard Model (SM) is one of the biggest open questions in physics nowadays. The vast majority of theoretically-motivated Ultralight-DM (ULDM) models predict that ULDM couples dominantly to the SM strong/nuclear sector. This coupling leads to oscillations of nuclear parameters that are detectable by comparing clocks with different sensitivities to these nature's constants. Vibrational transitions of molecular clocks are more sensitive to a change in the nuclear parameters than the electronic transitions of atomic clocks. Here, we propose the iodine molecular ion, I_2^+, as a sensitive detector for such a class of ULDM models. The iodine's dense spectrum allows us to match its transition frequency to that of an optical atomic clock (Ca^+) and perform correlation spectroscopy between the two clock species. With this technique, we project a few-orders-of-magnitude improvement over the most sensitive clock comparisons performed to date. We also briefly consider the robustness of the corresponding "Earth-bound" under modifications of the Z_N-QCD axion model.

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