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Experimental Constraint on Dark Matter-Standard Model Coupling with Optical Atomic Clocks

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All the evidence for existence of the dark matter (DM) comes from astrophysical observations at the galaxy scale. The nature of the DM composition, however, will be known only after the positive detection of the DM candidates. The nonbaryonic DM is most probably described by fields not yet included in the standard model. The viable cold DM particles candidates, axions, WIMPs, super- WIMPs, require existence of fields which can be coupled to the standard model fields. Therefore, existing experiments focus on searches for such couplings. Unfortunately, no experimental data proved any positive detection. E.g., the LUX experiment, which studied potential coupling between WIMPs and nucleons, reported recently constraints on the scattering cross section per nucleon below 1045 cm2 . Lack of any detected DM in the form of particles yielded alternative theories, such as oscillating massive scalar fields or topological defects in the scalar fields. Recently, we have shown that a single optical atomic clock can be used as a detector for the DM in the form of stable topological defects. We exploited differences in the susceptibilities to the fine structure constant of essential parts of an optical atomic clock, i.e. the atoms and the cavity. With a system of two strontium optical lattice clocks we performed an experiment which constrained the strength of atomic coupling to hypothetical DM cosmic objects. Under the conditions of our experiment, the degree of constraint was found to exceed the previously reported limits by more than three orders of magnitude.