DAMOP16-2016-000036
Abstract for an Invited Paper
for the DAMOP16 Meeting of
the American Physical Society

Manifestations of Dark matter and variation of the fundamental constants in atomic and astrophysical phenomena

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Low-mass boson dark matter particles produced after Big Bang form classical field and/or topological defects. In contrast to traditional dark matter searches, effects produced by interaction of an ordinary matter with this field and defects may be first power in the underlying interaction strength rather than the second or fourth power (which appears in a traditional search for the dark matter). This may give a huge advantage since the dark matter interaction constant is extremely small. Interaction between the density of the dark matter particles and ordinary matter produces both slow cosmological evolution and oscillating variations of the fundamental constants including the fine structure constant alpha and particle masses [1]. Recent atomic dysprosium spectroscopy measurements and the primordial helium abundance data allowed us to improve on existing constraints on the quadratic interactions of the scalar dark matter with the photon, electron and light quarks by up to 15 orders of magnitude. Limits on the linear and quadratic interactions of the dark matter with W and Z bosons have been obtained for the first time. In addition to traditional methods to search for the variation of the fundamental constants (atomic clocks, quasar spectra, Big Bang Nucleosynthesis, etc) we discuss variations in phase shifts produced in laser/maser interferometers (such as giant LIGO, Virgo, GEO600 and TAMA300, and the table-top silicon cavity and sapphire interferometers) [2], changes in pulsar rotational frequencies (which may have been observed already in pulsar glitches), non-gravitational lensing of cosmic radiation and the time-delay of pulsar signals [3]. Other effects of dark matter and dark energy include apparent violation of the fundamental symmetries: oscillating or transient atomic electric dipole moments, precession of electron and nuclear spins about the direction of Earths motion through an axion condensate, and axion-mediated spin-gravity couplings [4-6], violation of Lorentz symmetry and Einstein equivalence principle [7,8]. Finally, we explore a possibility to explain the DAMA collaboration claim of dark matter detection by the dark matter scattering on electrons. We have shown that the electron relativistic effects increase the ionization differential cross section up to 3 orders of magnitude [9]. References: [1] Y. V. Stadnik and V. V. Flambaum. Phys. Rev. Lett. 115, 201301 (2015). [2] Y. V. Stadnik, V. V. Flambaum. Phys. Rev. Lett. 114, 161301 (2015). 1511.00447 [3] Y. V. Stadnik, V. V. Flambaum. Phys. Rev. Lett. 113, 151301 (2014). [4] Y. V. Stadnik, V. V. Flambaum. Phys. Rev. D 89, 043522 (2014). [5] B. M. Roberts, Y. V. Stadnik, V. A. Dzuba, V. V. Flambaum, N. Leefer, D. Budker. Phys. Rev. Lett. 113, 081601 (2014). [6] B. M. Roberts, Y. V. Stadnik, V. A. Dzuba, V. V. Flambaum, N. Leefer, D. Budker. Phys. Rev. D 90, 096005 (2014). [7] V.A. Dzuba, V.V. Flambaum, M. Safronova, S.G. Porsev, T. Pruttivarasin, M.A. Hohensee, H. Haffner. NaturePhysics(2016). V.V. Flambaum.1511.04848 [9] B. M. Roberts, V. V. Flambaum, G. F. Gribakin, Phys. Rev. Lett. 116, 023201 (2016).