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Constraints for fundamental short-range forces from the neutron whispering gallery, and extention of this method to atoms and antiatoms (updated)

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Extra fundamental short-range interactions mediated by new bosons are predicted in many extensions of the Standard Model of particle physics. They are also predicted in theories with large extra spatial dimensions and theories involving the light dark matter hypothesis. To search for such interactions at different characteristic distances, the experimentalists use
many methods including measurements of gravitational interaction at short distances, the search for extra interactions on top of the van der Waals/Casimir-Polder interaction, the search for rare processes in neutrino detectors, precision measurements with atoms, molecules and neutrons. Comparison of the sensitivities of different experiments to extra short-range forces in the standard Yukawa parametrization is published, for example, in ref. [1]. A competitive method of searching at characteristic distances of about 10 nm is the precision measurement of the neutron whispering gallery [2]. This phenomenon is analogous to the well-known phenomenon of the whispering gallery of electromagnetic waves of a broad frequency range, as well as the sound wave. However, a material wave, for example a neutron wave, provides an additional possibility due to the existence of a nonzero neutron mass: for a neutron, the energy values of the whispering-gallery quantum states depend on the mass of the neutron and the interactions of this mass with the surface. Moreover, the neutron in such quantum states is localized at a distance from the surface of the order of tens of nano-meters. Even a tiny extra force between the neutron and the surface at such distances would lead to a measurable shift in the energy of whispering-gallery quantum states. We present the results of experiments performed with cold neutrons and estimate their sensitivity to extra short-range forces. Calibration experiments and detailed analysis are going to be done in summer 2018. We affirm that this method can also be extended to experiments with atoms and antiatoms [3]. The sensitivity of atomic experiments may be even higher than thus providing a similar, or even higher than the sensitivity of neutron experiments. More details could
be found in [4].

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[1] I. Antoniadis et al., Compt. Rend. Phys. 12 (2011) 755.
[2] V.V. Nesvizhevsky et al., Nature Phys. 6 (2010) 114.
[3] A.Yu. Voronin et al., Phys. Rev. A 85 (2012) 014902.
[4] V.V. Nesvizhevsky and A.Yu. Voronin, Surprising Quantum Bounces (Imperial College Press, London, UK, 2015).

Selected session

Fundamental Symmetries

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