Contribution ID: **40** Type: **Talk**

Search for additional fundamental interactions using whispering gallery quantum states of neutral particles.

Tuesday 4 July 2023 09:00 (35 minutes)

The Standard Model of particle physics perfectly describes most of the observed phenomena, but leaves a number of problems unresolved, including the origin of the matter-antimatter asymmetry, the nature of dark matter, the absence of observed CP violation in the strong sector, the fine tuning needed for light Higgs. Most extensions of the Standard Model involve the introduction of new fundamental interactions in addition to the four known ones. Such interactions can be spin-independent or spin-dependent. An experimental search for such interactions is carried out by a wide range of methods, each of which has an optimal sensitivity in a certain range of characteristic distances. One such method is the precision measurement of the whispering gallery quantum states of neutral particles. Such states are analogous to the gravitational quantum states of neutral particles up to the replacement of the gravitational force by the effective centrifugal one. Neutron whispering gallery quantum states were observed and made it possible to provide a competitive constraint on extra interactions with a characteristic range of ˜10 nm. The advantage of the whispering gallery states is the fact that by choosing the mirror diameter and particle velocity, one can "fine-tune"the sensitivity of the experiment to the characteristic distance of the extra interaction. A further dramatic improvement in accuracy in experiments with neutrons is possible, but requires both a more accurate theoretical description of these states and a more precise characterization of the curved mirrors used for these experiments. One of the most precise methods for characterizing mirrors is to measure a related phenomenon: the whispering gallery of X-rays. Such measurements have been carried out and their results are currently being analyzed. Another potential method for increasing accuracy is to measure the quantum states of the whispering gallery of atoms; this method makes it possible to obtain a much higher statistical sensitivity, and the accuracy and reliability of the theoretical description of this phenomenon is of the same order as with neutrons. Experiments with atomic hydrogen are being prepared. Interesting additional possibilities are experiments with composite particles, including antiparticles (antihydrogen, muonium, positronium). Theoretical analysis of such systems continues. Separate parts of this scientific program will be presented in other reports at this conference, and research is carried out both within the framework of collaborations (GRASIAN, GBAR) and by individual scientists. Some progress in most of these areas is expected soon.

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Session Classification: Interferometry