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Ultrasensitive Searches for the Axion[1]

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After thirty years, the axion, a hypothetical elementary particle, still represents the best solution to the Strong-CP problem, i.e. why the neutron has a vanishingly small electric dipole moment. If it exists at all, the axion must be extremely light, not much heavier than a millielectronvolt, but not much lighter than a microelectronvolt. At the lower end of the mass window, the axion also represents an excellent dark matter candidate. Furthermore, in addition to being exceedingly light, the axion possesses extraordinarily feeble couplings to matter and radiation, far below those of the weak interaction. Being a pseudoscalar however, like the neutral pion, the axion can couple to two photons, and as recognized by Pierre Sikivie in 1983, the axion can therefore convert to a single real photon in an external electromagnetic field, an effect historically known in pion physics as the Primakoff interaction. The coherent mixing of axions and photons in strong magnetic fields of large spatial extent has thus become the primary strategy for virtually all searches for the axion, which otherwise lies far beyond reach of any conventional particle physics experiment. This talk will review three major experimental efforts to discover the axion by coherent axion-photon mixing: the microwave cavity search for halo dark matter axions (AMDX); a search for solar axions (CAST); and purely laboratory experiments, looking for magnetically-induced dichroism and birefringence of the vacuum (PVLAS), and photon regeneration.

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