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J. J. Sakurai Prize: Astrophysics, Cosmology and PQ Symmetry–Linking the Very Small and the Very Large

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The symmetry between the laws of physics for matter and those for antimatter (technically known as CP symmetry) is broken in the weak interaction but maintained to a high level of precision in the strong interaction. In the context of the Standard Model theory of particles and their interactions this is a puzzle –what protects the strong interaction from being more "infected" by the lack of a symmetry of the weak interaction? I will review the history of the idea we had to solve this puzzle, its consequences, and its evolution into the versions still viable today. Our answer to this puzzle, adding a further symmetry now known as PQ symmetry, arose from thinking about the effects of quark-Higgs couplings as in the early Universe, in the phase transition that gives quarks their masses. Not only did this modification of the Standard Model arise from cosmological thinking, it turns out to have possible cosmological consequences in the form of a light, weakly-coupled particle known as the axion, a possible dark matter candidate. Furthermore astrophysical constraints on such a particle have played a role in the subsequent evolution of theories with PQ symmetry. I will review the early history of this fascinating linkage of large scale and small scale physics, leaving later developments for my collaborator and co-recipient of this prize, Roberto Peccei, to talk about.